NACA

RESEARCH MEMORANDUM

for the

Air Materiel Command, Army Air Forces

AERODYNAMIC CHARACTERISTICS OF A PORTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE WITH FABRIC-COVERED ELEVATORS

By Angelo Perone and Cecil L. Berthold

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

A Douglas C-74 airplane, during a test dive at about 0.525 Mach number, experienced uncontrollable longitudinal oscillations sufficient to cause shedding of the outer wing panels and the subsequent crash of the airplane. Tests of a section of the horizontal tail plane from a C-74 airplane were conducted in the Ames 16-foot high-speed wind tunnel to investigate the possibility of the tail as a contributing factor to the accident. The results of the investigations of fabric-covered elevators in various conditions of surface deformation are presented in this report. Bulging and sagging of the fabric were found to produce adverse effects on the elevator hinge-moment characteristics. An analysis of the dynamic pitching stability of the airplane together with the data obtained from these tests indicate that the longitudinal oscillations could have been caused by the elevator. Longitudinal dynamic instability is indicated to be less likely if the elevator surface deformation is minimized by fastening the fabric to the nose skin and doubling the number of ribs. During tests of one elevator of the same construction as on the airplane, the fabric tore loose from several of the ribs. This failure resulted in extreme ballooning of the surface which seriously altered the hinge moments. It is possible that the crash of the airplane during its test flight was the result of ballooning, and possibly rupture, of the elevator fabric due to a similar failure of its rib fastenings.

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INTRODUCTION

Pursuant to requests from the Air Materiel Command, Army Air Forces, tests of a portion of the horizontal tail from a Douglas C-74 airplane were conducted in the Ames 16-foot high-speed wind tunnel in order to analyze the aerodynamic characteristics of the tail as a possible cause of the recent crash of one of these airplanes during a test flight.

The disaster occurred during a flight which was to have included a shallow dive at an indicated airspeed of 372 miles per hour with a 2g pull-out. Just before the accident, the airplane was started in a 10° to 15° nose-down dive from 12,000 feet altitude. The pilot had noticed a few vibrations giving about $\pm 0.2g$ acceleration but did not consider them to be serious. When an indicated airspeed of 345 miles per hour was reached at about 8000 feet altitude, the control stick moved back toward the pilot and away again, but no pitching of the airplane was noticed. Immediately thereafter, wild oscillatory pitching of the airplane started. The frequency was estimated by the pilot to be about one cycle per second and the oscillation persisted through four cycles, causing an estimated acceleration at the pilot's position of 10 to -5g. When the oscillations subsided the pilot saw that both wings had broken off just outside the outboard nacelles. The crew bailed out and the airplane crashed into high-tension power lines, exploded, and burned. Structural analyses made by the Douglas Aircraft Corporation substantiate the fact that, had these longitudinal oscillations of the airplane been caused by the elevator, shedding of the outer wing panels without failure of the tail could have resulted.

Due to the urgent need for knowledge of the cause of the accident, a full-scale portion of the horizontal tail was tested in the 16-foot wind tunnel in spite of the fact that the large size of the tail plane relative to the wind-tunnel test section introduced serious tunnel-wall interference, the magnitude of which could be only roughly approximated. Tests were conducted with the elevator fabric and its method of attachment in essentially four different conditions. The results and a brief analysis are presented in this report.

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MODEL AND APPARATUS

Tests were conducted of the portion of a Douglas C-74 horizontal tail extending from the inboard end of the elevator to a point about 15 feet outboard of that station. (See fig. 1.) The tail was mounted in the Ames 16-foot high-speed wind tunnel so that it spanned the test section as shown in figure 2. A gap of about one-half inch existed between the tunnel walls and the ends of the elevator.

The forces and moments were measured by the six-component balance system. The elevator and tab angles were set by hand. Hinge moments of both the control tab and the elevator were measured by means of calibrated electrical-resistance strain gages. A static calibration of elevator deflection with hinge moment was made by hanging weights at three spanwise locations along the aft portion of the elevator. Lines were painted on the elevator surface (fig. 3) to make the bulging more easily perceptible, and photographs were taken at various Mach numbers.

The average rib spacing of the original elevator was 13 inches. For tests involving decreased rib spacing the number of ribs was doubled, reducing the spacing to approximately 6.5 inches.

The following is a list of the pertinent dimensions of the complete horizontal tail plane of the Douglas C-74 airplane:

Span	660 in.
Root chord	200 in.
Projected tip chord	100 in.
Aspect ratio	4.45
Taper ratio	2:1
Airfoil section at root	NACA 0015 modified by extending trailing edge by 12 percent chord

Airfoil section at projected tip . . . NACA 0012 modified by extending trailing edge by 12 percent chord

Thickness at root . . . . 13.4 percent chord

Thickness at projected tip . . . . 10.7 percent chord

Balance nose shape . . . . . . Douglas $\frac{B + C}{2}$ (reference 1)

Balance (ratio of chord of balance area to elevator chord aft of hinge line . . . . . . 36.7 percent

SYMBOLS

The symbols and coefficients used in this report are defined as follows:

α angle of attack of the tail relative to the air stream, degrees

δ_e elevator angle relative to the stabilizer chord line (plus when trailing edge is down), degrees

δ_t elevator control-tab angle relative to the elevator chord line (plus when trailing edge is down), degrees

C_{h_e} elevator hinge-moment coefficient $\left(\frac{\text{hinge moment}}{q\, b_e\, \overline{c_e{}^2}}\right)$

C_{h_t} control-tab hinge-moment coefficient $\left(\frac{\text{hinge moment}}{q\, b_t\, \overline{c_t{}^2}}\right)$

C_L tail lift coefficient $\left(\frac{\text{lift}}{q\, S}\right)$

S area of the portion of the tail tested (193.78 sq ft)

b_e span of elevator tested (14.80 ft)

b_t span of control tab (9.583 ft)

$\overline{c_e{}^2}$ mean-squared elevator chord aft of hinge line for the portion of the tail tested (35.35 sq ft)

$\overline{c_t^2}$ mean-squared control-tab chord aft of hinge line (1.074 sq ft)

q dynamic pressure ($\frac{1}{2}\rho V^2$)

ρ density of free air stream, slugs per cubic foot

V velocity of free air stream, feet per second

V_i indicated airspeed, miles per hour

M Mach number, ratio of stream velocity to velocity of sound

$$C_{h_\alpha} = \left(\frac{\partial C_{h_e}}{\partial \alpha}\right)_{\delta_e}$$

$$C_{h_\delta} = \left(\frac{\partial C_{h_e}}{\partial \delta_e}\right)_{\alpha}$$

(The subscripts outside the parentheses represent the factors held constant during the measurement of the parameters.)

Subscript

u data uncorrected for constriction and tunnel-wall interference.

TESTS

The tests of the portion of the Douglas C-74 horizontal-tail plane were conducted with the elevator fabric in four different conditions.

The first of these was one in which the elevator fabric, at the start of the testing, was attached to the ribs by small screws and drawn over the metal nose skin but attached to it only by doping. Early in the course of the tests the fabric pulled loose from the nose skin and a bulge developed which, upon increasing in size, began tearing the fabric from its fastenings to the fore parts of the ribs. The bulging and detachment from the ribs rapidly extended from about 5 to 40 percent of the elevator chord and, in extreme cases, bulging up to an estimated 4 inches in height occurred over about one-half of the test span. Fabric sag varying in magnitude up to an estimated 1.5 inches in depth occurred between the ribs at the aft portion of the elevator over the complete test span. Typical bulging and sag of the elevator fabric for this condition is shown in figure 4. This first elevator condition will henceforth be referred to as the "original condition, fabric detached."

The second condition embodied reattachment of the fabric to the ribs and fastening to the metal nose skin by rows of screws along the rear edge of the nose skin and chordwise along the rib lines projected forward. The bulging was reduced considerably by this means and only slight bulges (not over 0.5 inch in height) at about the 10-percent-chord line resulted between the fastenings. Nothing was done to minimize the sag of the fabric between the ribs under air load, and the sucking in of the surfaces prevailed to approximately the same extent as with the first elevator condition. This second condition will be known as that with the elevator in the "original condition, fabric fastened."

Due to the urgency with which tests were made of these first two elevator conditions, the control-tab linkage was left almost as that on the airplane, and the tab was linked rigidly to the stabilizer. With this system, the control tab deflected relative to the elevator as the elevator deflected under load. Deformation of the linkage system also contributed to the tab deflection. Exact evaluation of the effect of this tab deflection was not possible but it is believed that it was such as to cause more positive C_{h_δ}.

The third elevator condition is hereinafter referred to as that of "decreased rib spacing, fabric fastened." In this case the number of ribs was doubled (reducing the rib spacing to 6.5 inches) and the fabric was fastened to all the ribs and to the nose skin. Deflection of the control tab was minimized by linking it to the elevator.

The fourth elevator condition was identical with the first, prior to testing, in representing the part directly off the airplane. However, the fabric on this elevator did not tear loose from the ribs and the bulging and sag were considerably less than that prevailing during tests of the first condition. (See fig. 5.) This fourth condition will be referred to as the "original condition." Control-tab characteristics were measured during this fourth set of tests.

REDUCTION OF DATA

Corrections have been applied to the aerodynamic coefficients according to the method of reference 2 modified for a circular closed-throat wind tunnel. The equations used for computing corrections for constriction and tunnel-wall effects were as follows:

$$\Delta\alpha = \frac{1.78\ C_{L_u}}{\sqrt{1-M_u{}^2}}$$

$$\Delta C_L = -\left\{\frac{0.1952}{1-M_u{}^2} + \frac{0.0608(2-M_u{}^2)}{(1-M_u{}^2)^{3/2}} + \frac{0.00524(2-M_u{}^2)[1+0.4(M_u)^2]}{1-M_u{}^2}\right\}C_{L_u}$$

$$\Delta C_{h_e} = \frac{0.0500}{1-M_u{}^2}\ C_{L_u}$$

$$\Delta C_{h_t} = \frac{0.030}{1-M_u{}^2}\ C_{L_u}$$

The theory from which the preceding equations have been derived assumes that the chord and thickness of the model are small relative to the size of the test section, that the airfoil section and chord are constant along the span, and that no end leakage exists near the tunnel walls. Each of these fundamental considerations was violated in the wind-tunnel tests of the C-74 tail, the deviation from the first being perhaps the most critical.

Unfortunately, the effect of the tunnel walls on the elevator hinge moments is that for which the corrections are the most uncertain. The corrections to the hinge-moment coefficients were as large as 0.030. With corrections that, in general, were larger than the actual values of the uncorrected coefficients, it must be understood that the so-called "corrected coefficients" are, at best, approximations. The magnitudes of the elevator hinge-moment coefficient corrections, for example, were in some cases enough to reverse the variation of hinge-moment coefficient with elevator angle.

RESULTS

The variation of hinge-moment coefficient with elevator angle is presented in figures 6 to 9 for all the conditions tested. The positive variation for the fabric-detached (fig. 6) and the fabric-fastened conditions (fig. 7) is apparent. A negative slope is shown when the fabric was fastened with decreased rib spacing (fig. 8) and for the original condition (fig. 9), the predominant feature being a less negative slope with increase of Mach number. In some cases the tunnel-wall corrections were of such magnitude as to convert a negative slope into a positive one. Therefore, the absolute values of the coefficients, in each case, are subject to question.

Figures 10 to 13 present the change of elevator hinge-moment coefficient with tail angle of attack for the different fabric conditions, the results, in general, being similar and indicating positive variations. The tail lift coefficient as a function of elevator angle is shown in figures 14 to 17.

The positive variation of C_L with δ_e at 0.20 Mach number was generally the same for all the fabric conditions tested. It is noticed that the slopes of these curves, for the conditions in which surface deformation was not minimized, decreased with increase of Mach number. The negative elevator effectiveness which resulted with increase of Mach number for the elevator in the original condition most likely was due to fabric bulge of a type unique to this fabric condition.

The effect of Mach number on the aerodynamic parameters C_{h_δ} and C_{h_α} is shown in figures 18 to 20 for all the conditions except that with the fabric detached. Symbols used in these plots represent the results of cross plots of the original data. The C_{h_α} variation was similar for all elevators tested, tending to increase with increasing Mach number.

Control-tab effectiveness data were obtained for the elevator in the original condition. The results in figure 21 show decreasing effectiveness $dC_{h_e}/d\delta_t$ with increase of Mach number.

Figure 22 presents the results of an analysis of the dynamic pitching stability of the C-74 airplane made by the Douglas Aircraft Corporation according to the method of reference 3. The flight conditions for which the critical boundaries have been calculated are approximately those under which the accident occurred to the airplane. The experimental data included in the figure are for the fabric-fastened - decreased rib spacing and fabric-fastened conditions. Due to load limits, not enough data were available for the conditions without the fabric fastened to present more test results on the pitching-stability plot. The uncertainty of the tunnel-wall corrections is especially critical in applying this curve as only a slight error in their magnitudes could cause a shift of the experimental points, thereby either denoting stability or instability.

Figure 23 shows the variation of the indicated air speed with Mach number in the wind tunnel. It is probable that the elevator surface deformation and aerodynamic characteristics were at least partly affected by the increase in dynamic pressure with increase of Mach number. In applying the results of the wind-tunnel tests, the values of indicated airspeed should be considered along with the Mach number.

DISCUSSION

During the tests of an elevator similar to that on the airplane, detachment of the fabric from some of the ribs occurred. This failure was accompanied by surface ballooning of such severity that, had testing at the high Mach numbers continued, complete fabric failure might have resulted. It is possible that the events directly preceding the oscillations of the airplane (i.e., the uncontrollable fore and aft motions of the control stick) were due to similar fabric detachment and ballooning. The possibility exists that rupture of part of the fastenings securing the fabric to the elevator ribs permitted a sudden ballooning of the fabric, which in turn caused sudden changes in the elevator hinge moment. These sudden changes in hinge moment may have been the motivating force behind the elevator oscillations; the effect on the stick was noticed by the pilot. During the course of these elevator oscillations, progressive detachment of the fabric may have also contributed to the oscillatory pitching of the airplane. On the basis of tests of the Douglas C-74 tail and upon consideration of the symptoms leading to the crash of the airplane, it appears quite possible that the accident was the result of ballooning of the elevator fabric due to failure of its fastenings during the test flight.

It is shown on figure 22 that either stable or unstable dynamic pitching-moment conditions of the airplane are possible, dependent on the extent to which elevator surface deformation occurs. Unfortunately, it is impossible to reach any definite conclusion from this curve due to the uncertainty of the absolute values of the data. It is evident, however, that for greater dynamic longitudinal stability more negative values of Ch_δ are required. The effect of bulge and sag, in general, was to cause more positive Ch_δ values. The bulging of the fabric over the nose of the elevator changed the nose balance shape to one of greater bluntness. A more blunt nose shape can produce more positive Ch_δ values (reference 1), which would be especially detrimental with a closely balanced elevator of this type. Adverse effects are also attributed, in part, to the beveled trailing-edge section resulting from sag of the fabric between ribs at the aft portion of the elevator. The beveled edge in this case was composed of the trim and control tabs whose surfaces did not deform appreciably under load. Results of flight tests of elevator sections have shown more positive Ch_δ values resulting from beveled trailing edges (reference 4). Wind-tunnel data for beveled trailing-edge elevators having overhanging balance and a blunt nose have shown overbalance at high Mach numbers (reference 5). Elimination of the overbalance, in that case, resulted upon changing to straight-sided elevators. The results obtained from tests of the C-74 elevator show that the only fabric condition in which Ch_δ remained negative with increase in Mach number was that where the surface deformation was held to a minimum by fabric fastening and decreased rib spacing. Fabric fastening and decreased rib spacing may not be the safest solution, however, as upon aging and deterioration of the fabric, it is possible that bulging and sagging may recur with accompanying adverse effects. This consideration suggests the use of metal-covered elevators.

After fabric bulge and sag have been reduced to a minimum, still greater longitudinal dynamic stability of the airplane may be obtained by using a sharper nose section or by decreasing the area of the overhanging balance (reference 6). Similar results may also be obtained by extension of the trailing edge, a change which in effect amounts to a decrease in balance. It is recommended that should further tests be conducted for investigation of the effect of these modifications, a smaller model be used so that the absolute values of the aerodynamic coefficients can be obtained more accurately.

CONCLUDING REMARKS

Due to the magnitude and uncertainty of the tunnel-wall corrections, the absolute values of the aerodynamic coefficients of the Douglas C-74 tail are subject to question. From results of tests of an elevator in various conditions of surface deformation and on the basis of an analysis of the dynamic pitching-moment characteristics of the airplane, it is indicated that fabric bulge and sag may have caused unstable oscillatory flight and the crash of the airplane. Less likelihood of longitudinal dynamic instability was indicated when the elevator surface deformation was minimized. In tests of an elevator identical to that on the Douglas C-74 airplane the fabric tore loose from the ribs and severe surface ballooning accompanied by large changes in the hinge moments occurred. It is possible that the symptoms leading to the crash of the airplane were caused by the fabric tearing loose from the ribs.

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FIGURE LEGENDS

Figure 1.- Dimensions of the portion of the Douglas C-74 tail tested in the 16-foot wind tunnel.

Figure 2.- Three-quarter rear view of the portion from a Douglas C-74 tail being mounted in the Ames 16-foot high-speed wind tunnel.

Figure 3.- Location of lines to show deformation of fabric on C-74 elevator.

Figure 4.- Type of surface deformation for the Douglas C-74 elevator during tests in the Ames 16-foot high-speed wind tunnel fabric detached condition. $\alpha=0^\circ$. $\delta_e=2^\circ$. M=0.55.

Figure 5.- Photographs showing differences in bulging for the upper surfaces of two similar elevators tested in the Ames 16-foot high-speed wind tunnel. (a) Fabric loose. (b) Original condition.

Figure 6.- Variation of elevator hinge-moment coefficient with elevator angle for a section of the horizontal tail from a Douglas C-74 airplane. Original condition - fabric detached. M=0.2.

Figure 7.- Variation of elevator hinge-moment coefficient with elevator angle for a section of the horizontal tail from a Douglas C-74 airplane. Original condition - fabric fastened. (a) M=0.20. (b) M=0.40.

Figure 7.- Concluded. (c) M=0.50. (d) M=0.55. (e) M=0.60.

Figure 8.- Variation of elevator hinge-moment coefficient with elevator angle for a section of the horizontal tail from a Douglas C-74 airplane. Decreased rib spacing - fabric fastened. (a) M=0.20. (b) M=0.40.

Figure 8.- Concluded. (c) M=0.50. (d) M=0.55. (e) M=0.60.

Figure 9.- Variation of elevator hinge-moment coefficient with elevator angle for a section of the horizontal tail from a Douglas C-74 airplane. Fabric in original condition. (a) M=0.20. (b) M=0.40.

Figure 9.- Concluded. (c) M=0.50. (d) M=0.525. (e) M=0.55.

Figure 10.- Variation of elevator hinge-moment coefficient with tail angle of attack for a section of the horizontal tail from a Douglas C-74 airplane. Original condition - fabric detached. M=0.20.

Figure 11.- Variation of elevator hinge-moment coefficient with tail angle of attack for a section of the horizontal tail from a Douglas C-74 airplane. Original condition - fabric fastened. (a) M=0.20. (b) M=0.40.

Figure 11.- Concluded. (c) M=0.50. (d) M=0.55. (e) M=0.60.

Figure 12.- Variation of the elevator hinge-moment coefficient with tail angle of attack for a section of the horizontal tail from a Douglas C-74 airplane. Fabric fastened - decreased rib spacing. (a) M=0.20. (b) M=0.40.

Figure 12.- Concluded. (c) M=0.50. (d) M=0.55. (e) M=0.60.

Figure 13.- Variation of elevator hinge-moment coefficient with tail angle of attack for a section of the horizontal tail from a Douglas C-74 airplane. Fabric in original condition. (a) M=0.20. (b) M=0.40.

Figure 13. Concluded. (c) M=0.50. (d) M=0.525. (e) M=0.55.

Figure 14.- Variation of tail lift coefficient with elevator angle for a section of the horizontal tail from a Douglas C-74 airplane. Original condition - fabric detached. M=0.20.

Figure 15.- Variation of tail lift coefficient with elevator angle for a section of the horizontal tail from a Douglas C-74 airplane. Original condition - fabric fastened. (a) M=0.20. (b) M=0.4.

Figure 15.- Continued. (c) M=0.50. (d) M=0.55.

Figure 15. Concluded. (e) M=0.60.

Figure 16.- Variation of tail lift coefficient with elevator angle for a section of the horizontal tail from a Douglas C-74 airplane. Fabric fastened - decreased rib spacing. (a) M=0.2. (b) M=0.4.

Figure 16.- Continued. (c) M=0.50. (d) M=0.55.

Figure 16.- Concluded. (e) M=0.60.

Figure 17.- Variation of tail lift coefficient with elevator angle for a section of the horizontal tail from a Douglas C-74 airplane. Fabric in original condition. (a) M=0.20. (b) M=0.40.

Figure 17.- Concluded. (c) M=0.50. (d) M=0.525. (e) M=0.55.

Figure 18.- Variation of elevator hinge-moment parameters with Mach number for a section of the horizontal tail from a Douglas C-74 airplane. Original condition, fabric fastened.

Figure 19.- Variation of elevator hinge-moment parameters with Mach number for a section of the horizontal tail from a Douglas C-74 airplane. Fabric fastened - decreased rib spacing.

Figure 20.- Variation of elevator hinge-moment parameters with Mach number for a section of the horizontal tail from a Douglas C-74 airplane. Fabric in original condition.

Figure 21.- Variation of elevator hinge-moment with control tab angle for a section of the horizontal tail from a Douglas C-74 airplane. Fabric in original condition. $\alpha=0^{\circ}$. (a) M=0.20. (b) M=0.40.

Figure 21.- Concluded. (c) M=0.45. (d) M=0.50. (e) M=0.525. (f) M=0.55.

Figure 22.- C-74 airplane elevator-free longitudinal stability boundaries at constant speed. (Stability boundaries reproduced from figure prepared by Aerodynamics Department, Douglas Aircraft Co., Inc., 11-1-46.)

Figure 23.- Variation of indicated airspeed with Mach number for the conditions in the wind tunnel during tests of the horizontal tail from a Douglas C-74 airplane.

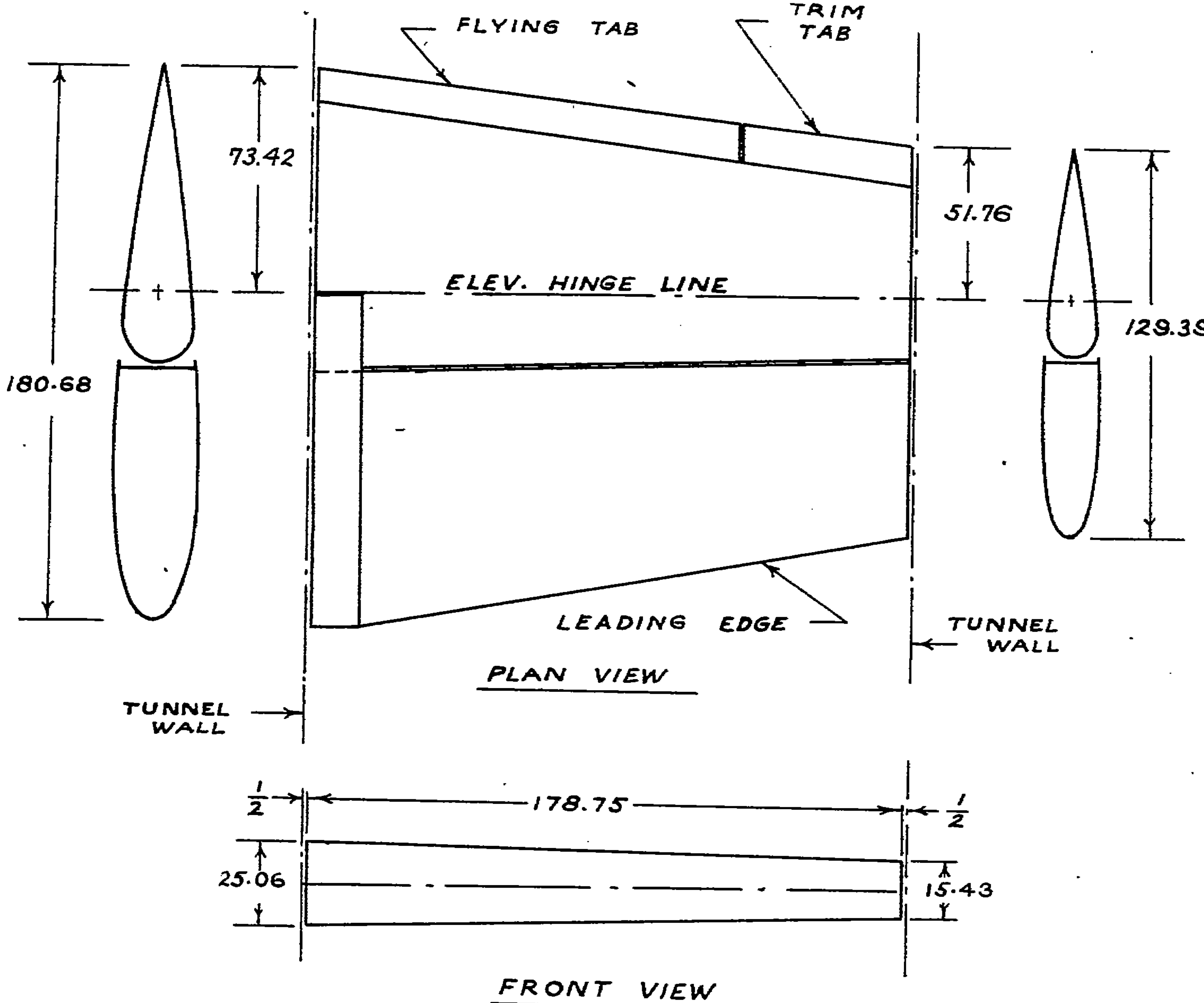

FIGURE 1. .- DIMENSIONS OF THE PORTION OF THE DOUGLAS C-74 TAIL TESTED IN THE 16-FOOT WIND TUNNEL.

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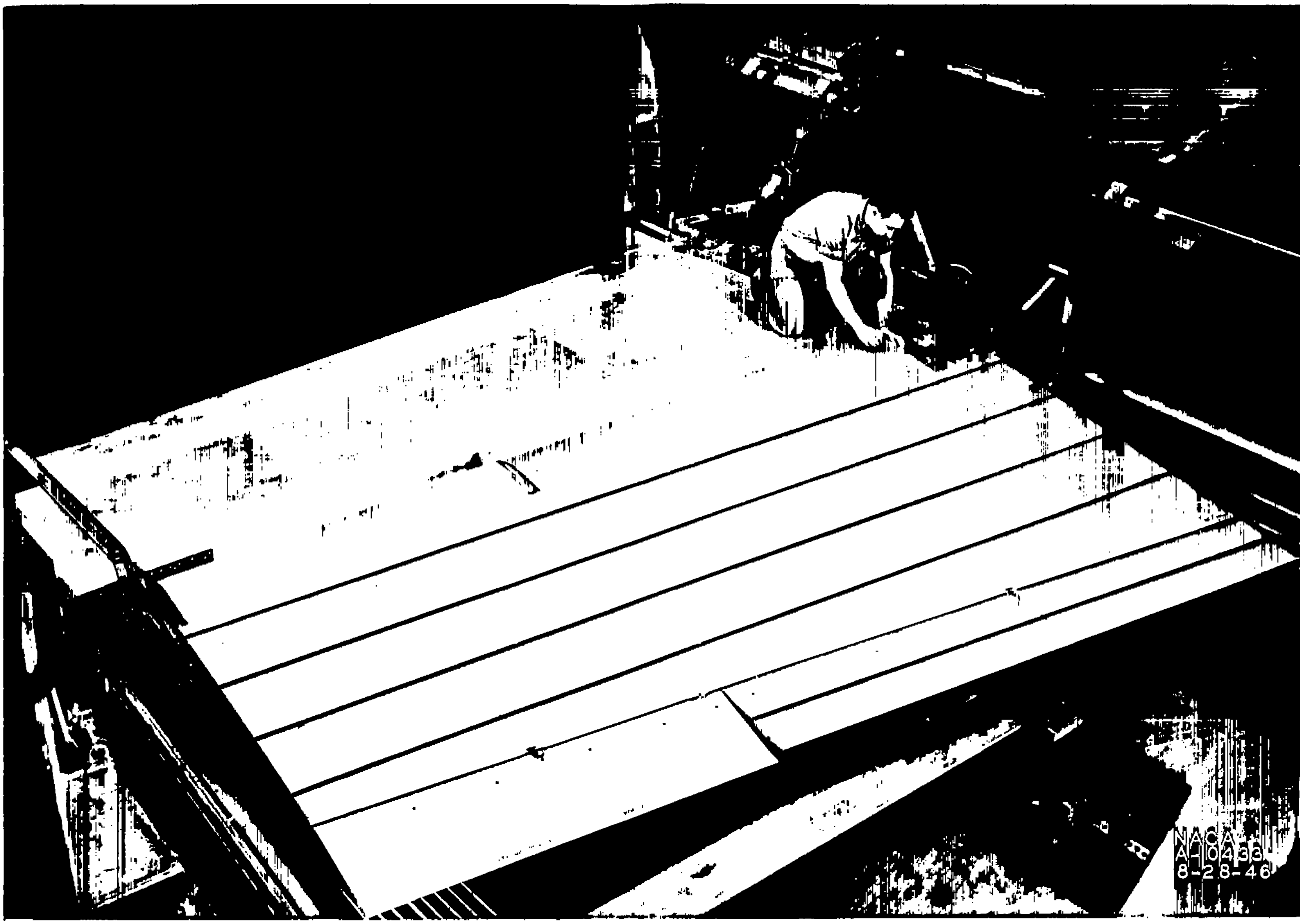

Figure 2.- Three-quarter rear view of the portion from a Douglas C-74 tail being mounted in the Ames 16-foot high-speed wind tunnel.

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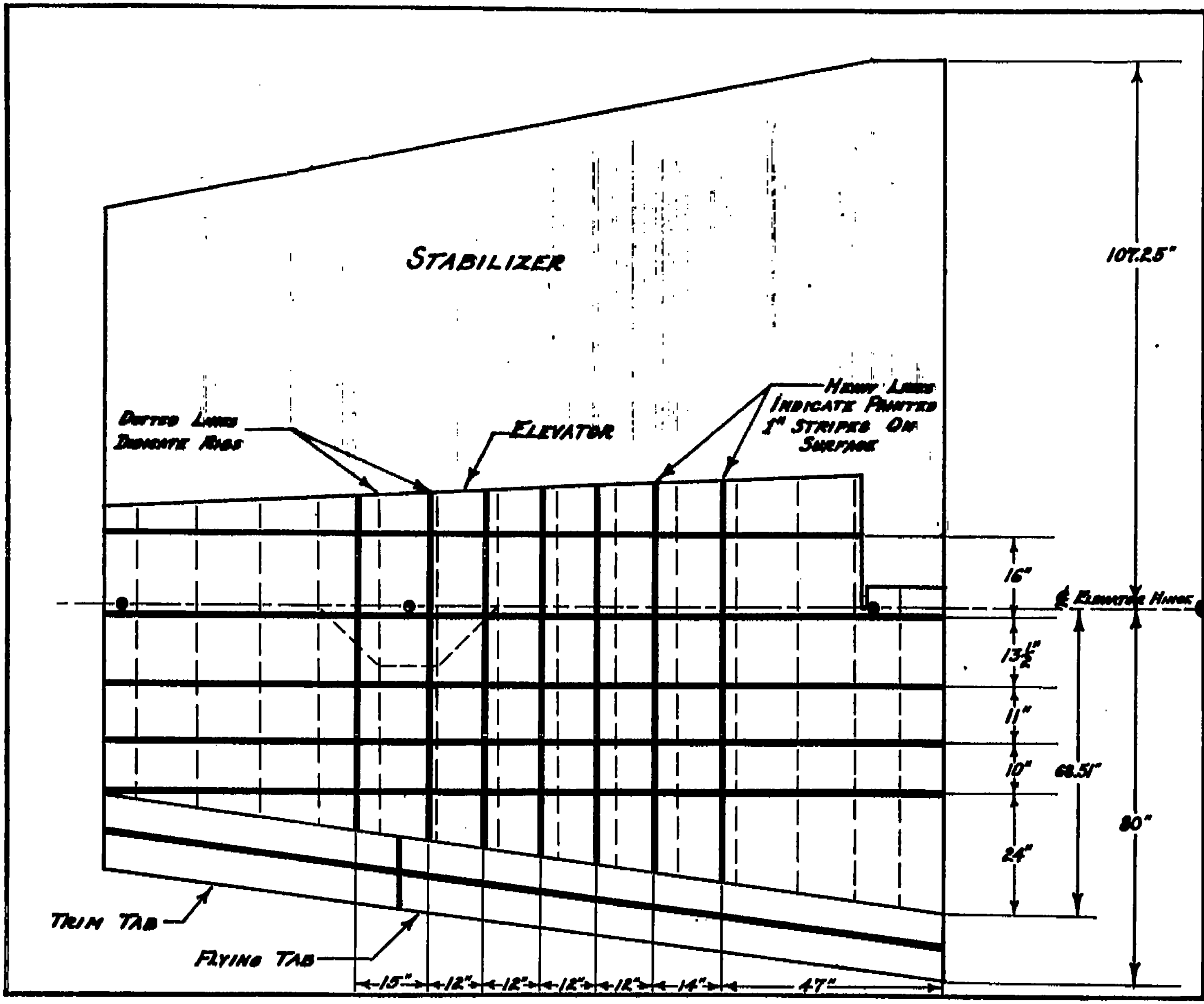

FIGURE 3.- LOCATION OF LINES TO SHOW DEFORMATION OF FABRIC ON C-74 ELEVATOR. [redacted]

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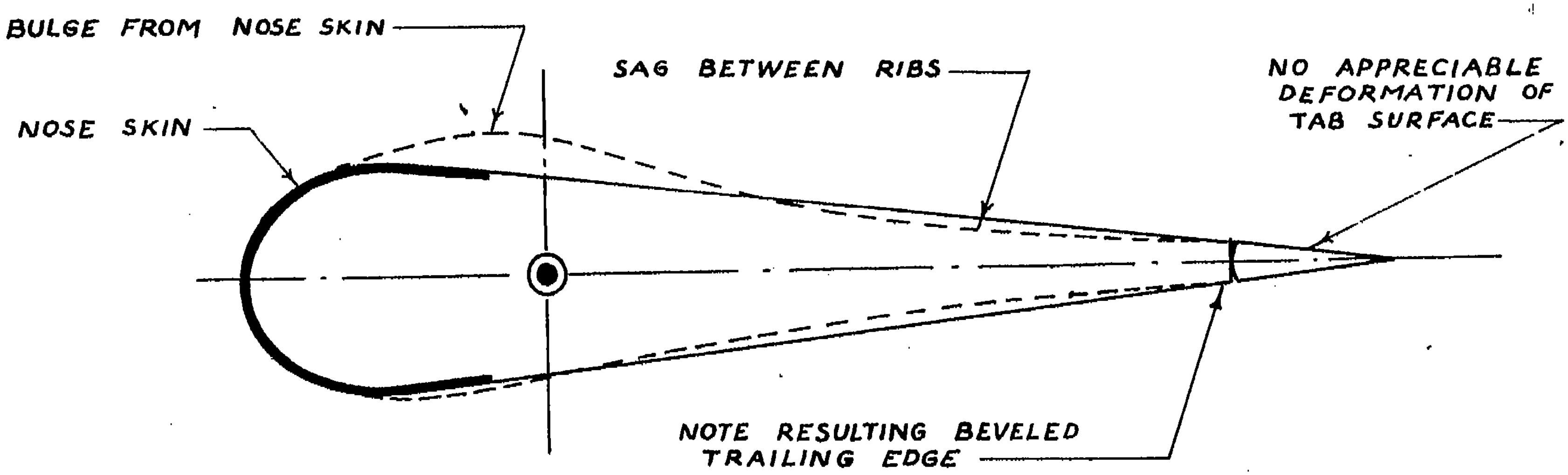

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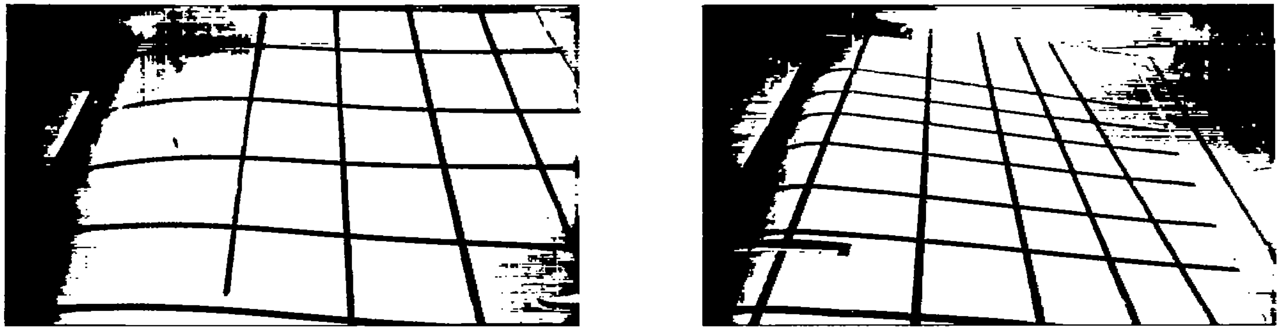
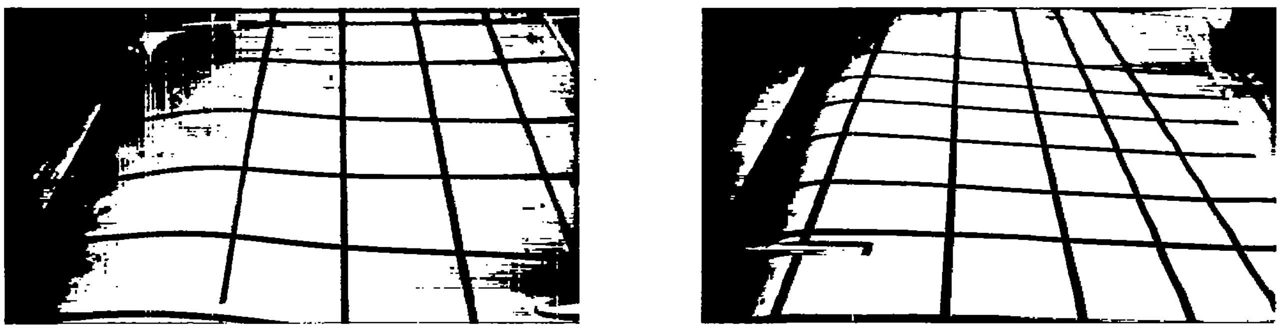
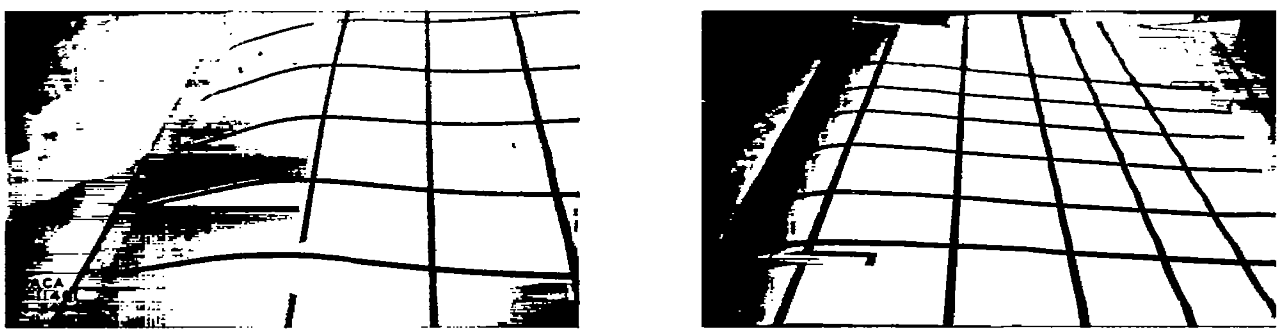
FIGURE 4.- TYPE OF SURFACE DEFORMATION FOR THE DOUGLAS C-74 ELEVATOR DURING TESTS IN THE AMES 16-FOOT HIGH-SPEED WIND TUNNEL FABRIC DETACHED CONDITION. $\alpha = 0°$ $\delta_e = +2°$ $M = 0.55$



$M = 0.2$
$\alpha = 0.3^\circ \quad \delta_e = 0.6^\circ$



$M = 0.4$
$\alpha = -0.2^\circ \quad \delta_e = -1.0^\circ$



$M = 0.5$
$\alpha = -0.3^\circ \quad \delta_e = -1.0^\circ$

(a) Fabric loose. (b) Original condition.

Figure 5.- Photographs showing differences in bulging for the upper surfaces of two similar elevators tested in the Ames 16-foot high-speed wind tunnel.

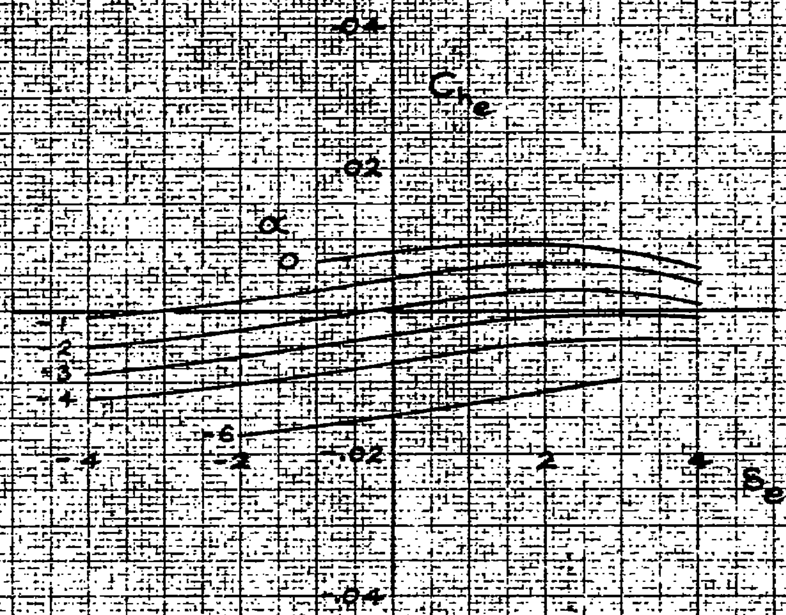


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FIGURE 6.— VARIATION OF ELEVATOR HINGE-MOMENT COEFFICIENT WITH ELEVATOR ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. ORIGINAL CONDITION — FABRIC DETACHED. M=0.2

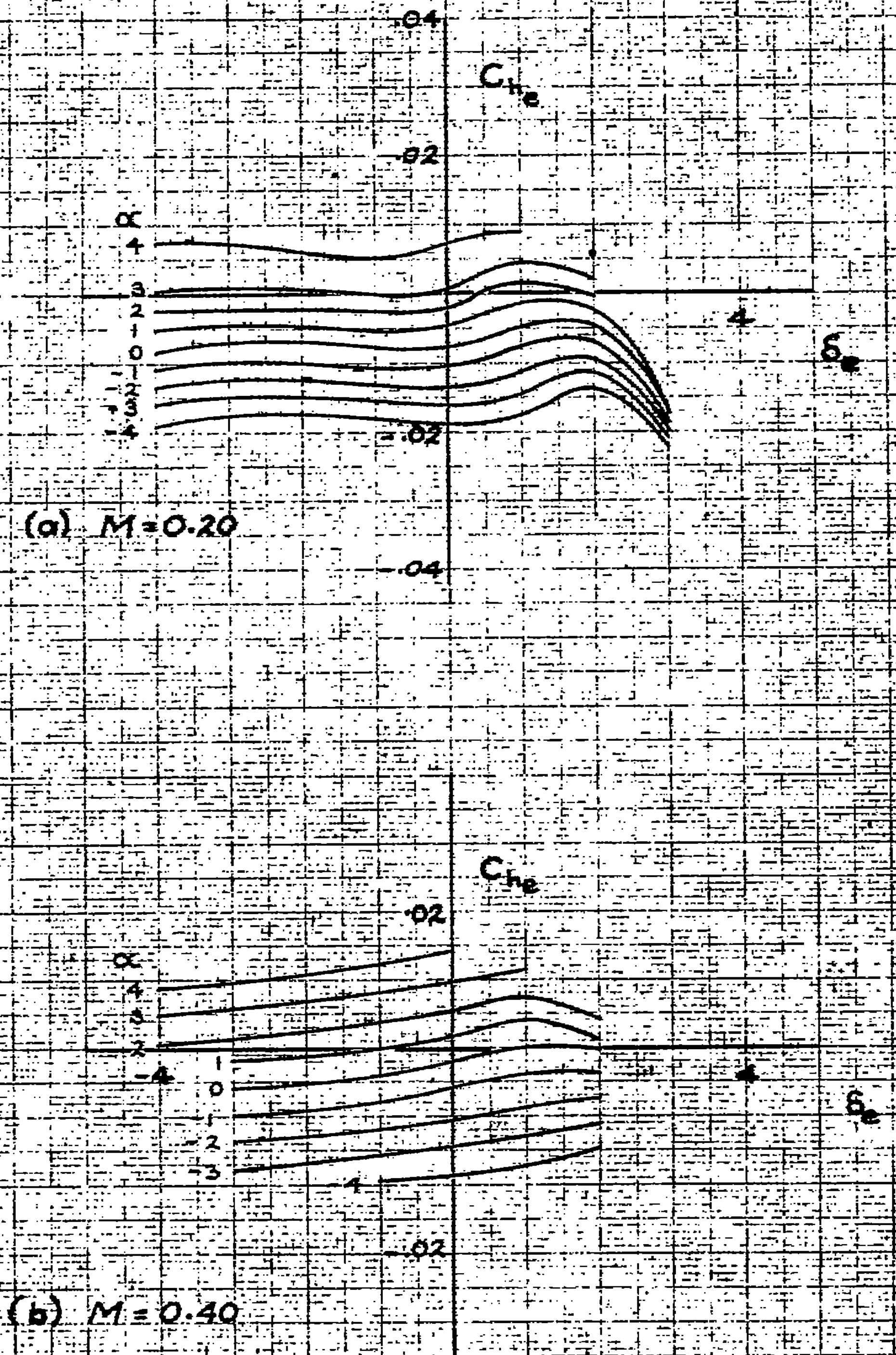

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FIGURE 7.- VARIATION OF ELEVATOR HINGE-MOMENT COEFFICIENT WITH ELEVATOR ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. ORIGINAL CONDITION—FABRIC FASTENED.

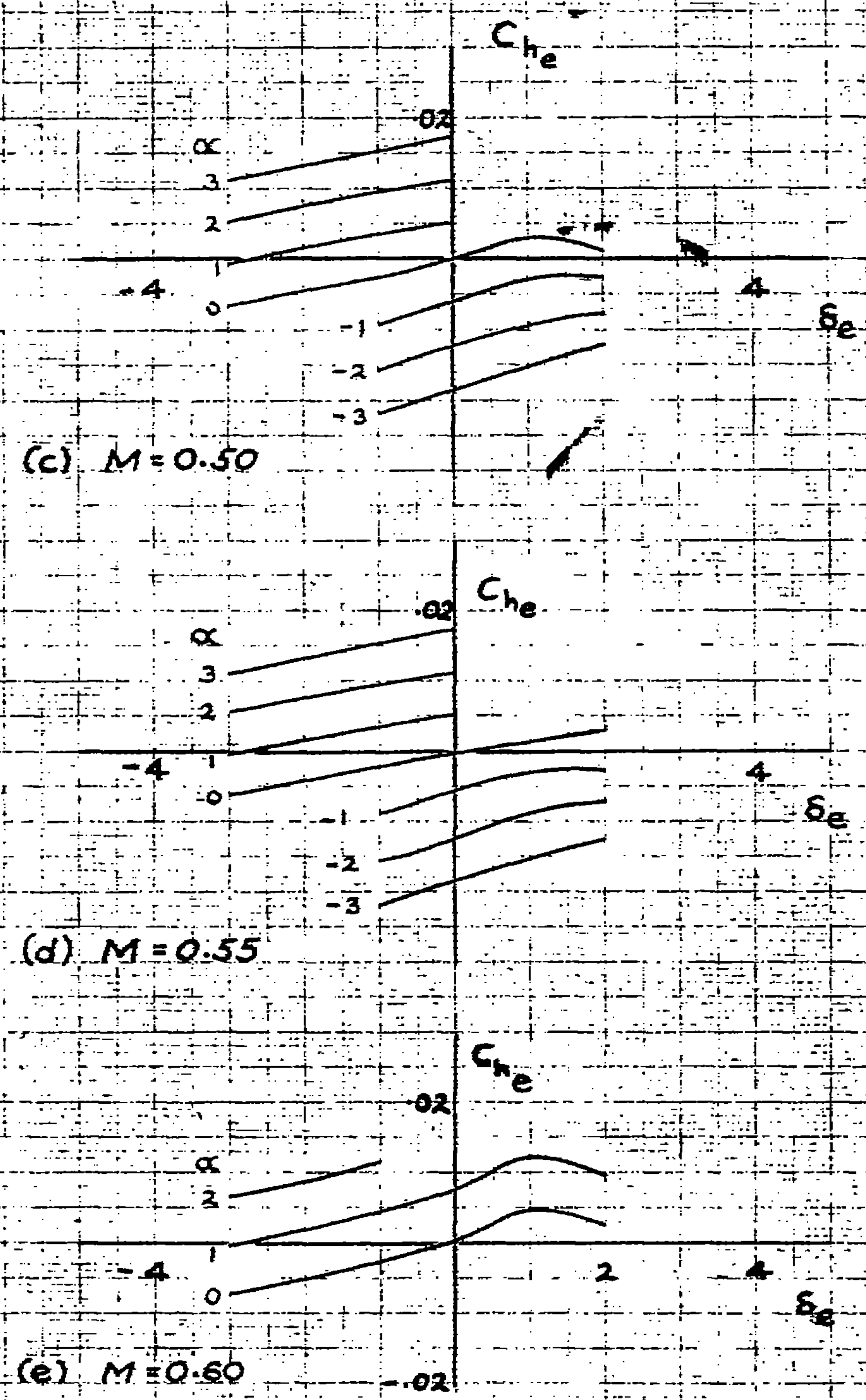

FIGURE 7.– (CONCLUDED)

[redacted]

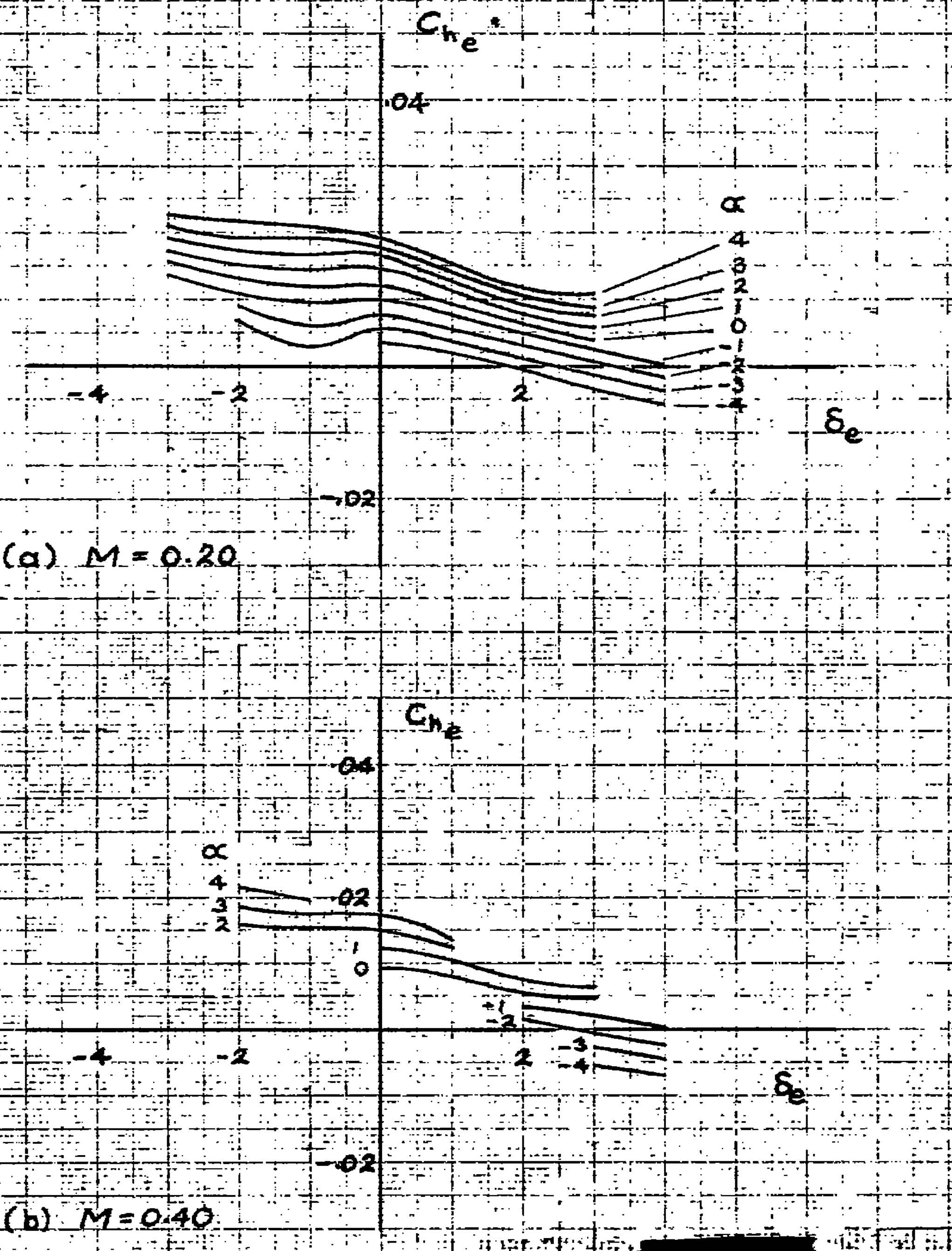

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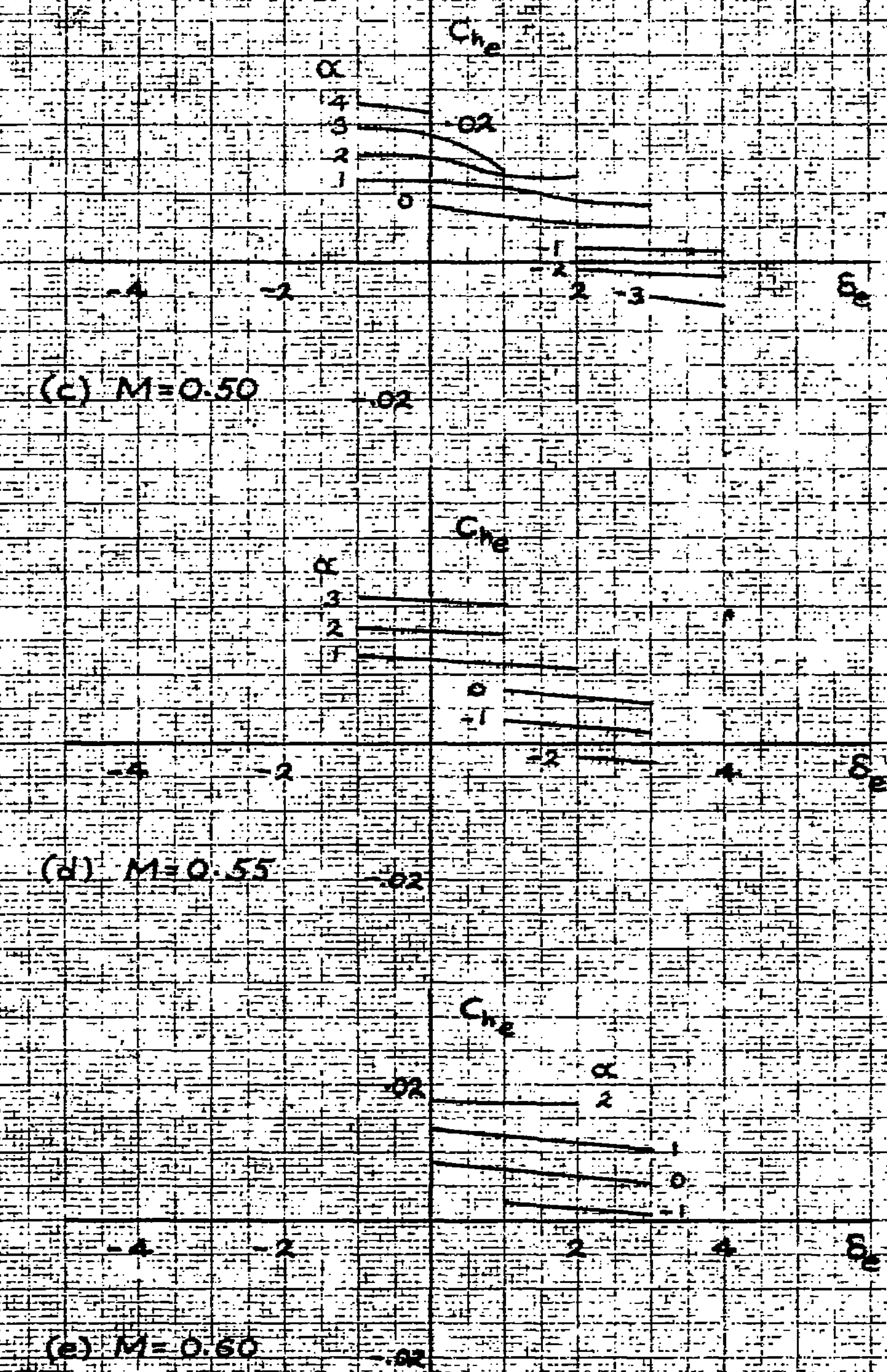
FIGURE 8.— VARIATION OF ELEVATOR HINGE-MOMENT COEFFICIENT WITH ELEVATOR ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. DECREASED RIB SPACING — FABRIC FASTENED.



(c) M=0.50

(d) M=0.55

(e) M=0.60

FIGURE 8.- (CONCLUDED)

[redacted]

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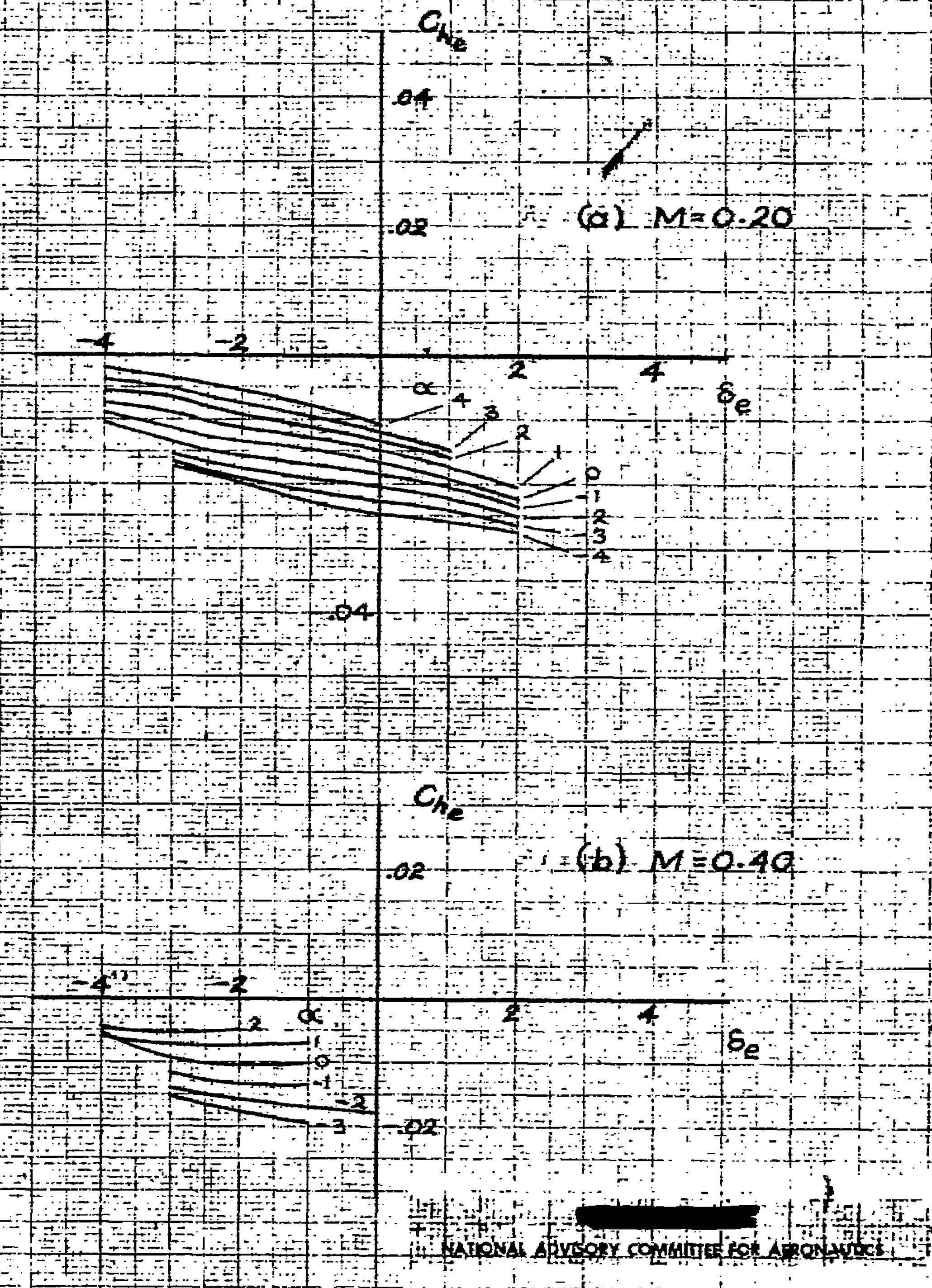


FIGURE 9.— VARIATION OF ELEVATOR HINGE-MOMENT COEFFICIENT WITH ELEVATOR ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. FABRIC IN ORIGINAL CONDITION.

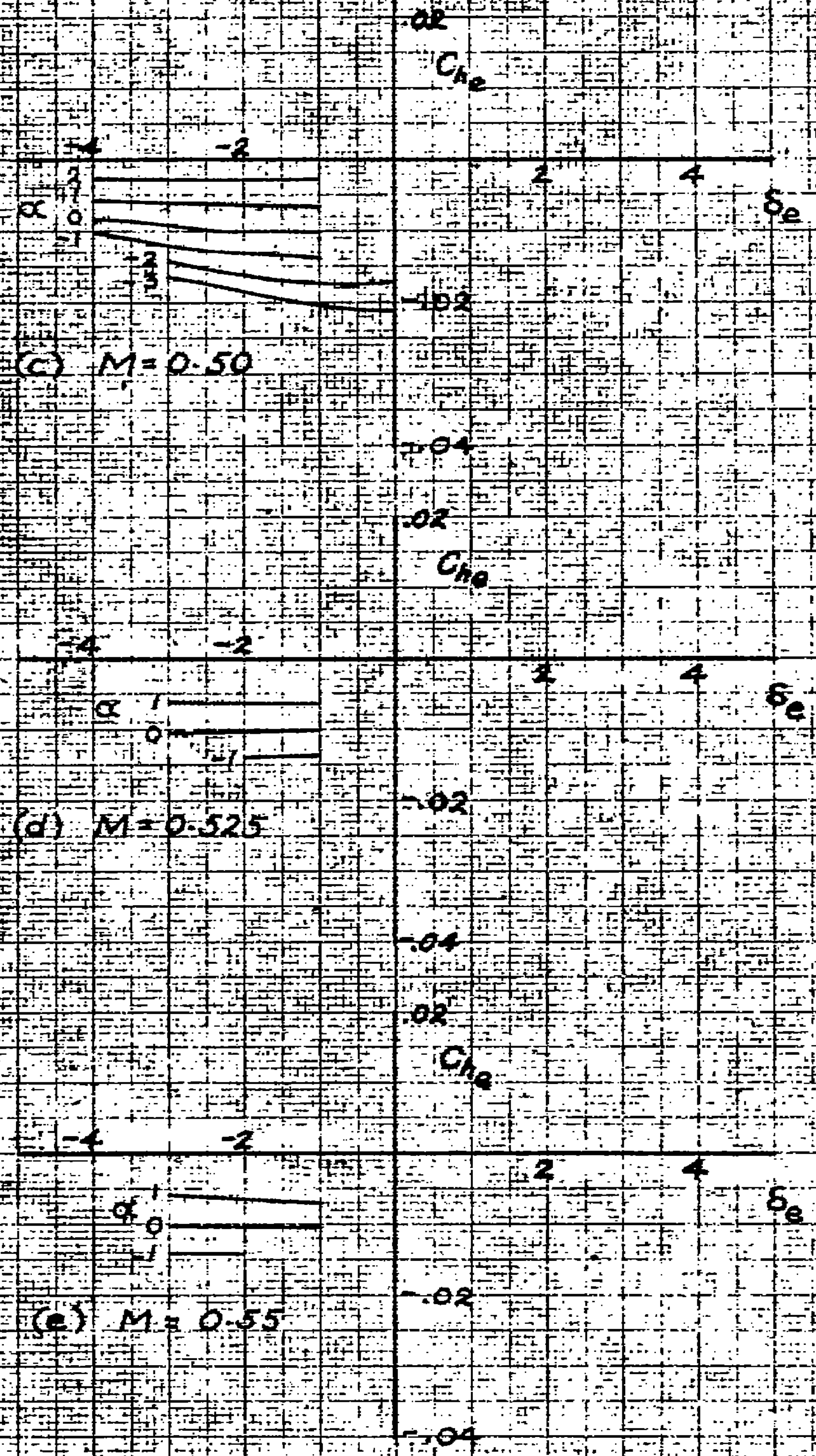
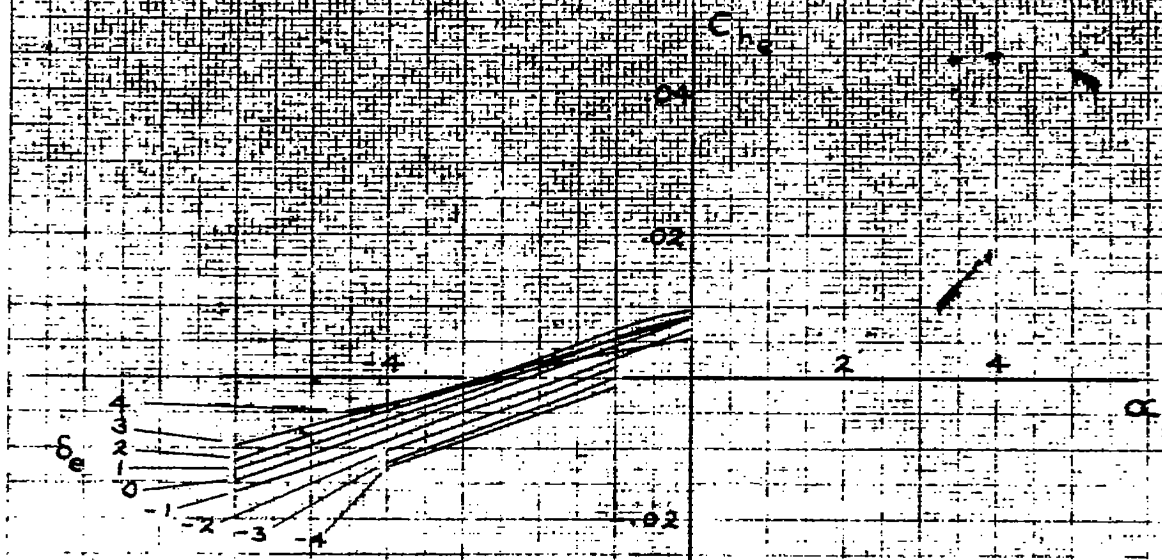


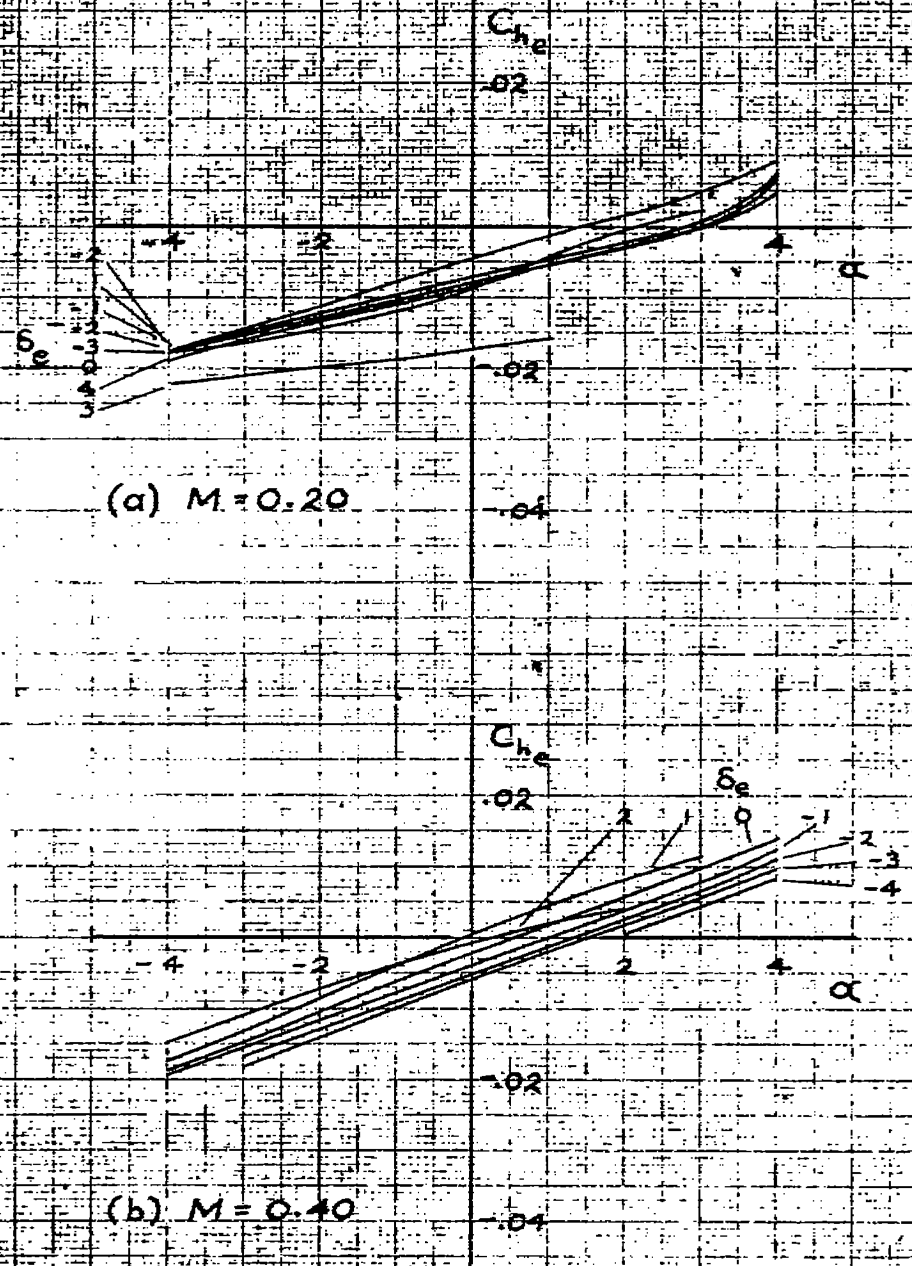
FIGURE 9.– (CONCLUDED)

[redacted]



[redacted]
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

FIGURE 10.– VARIATION OF ELEVATOR HINGE-MOMENT COEFFICIENT WITH TAIL ANGLE OF ATTACK FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. ORIGINAL CONDITION– FABRIC DETACHED. $M = 0.20$



[redacted]
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

FIGURE 11.— VARIATION OF ELEVATOR HINGE-MOMENT COEFFICIENT WITH TAIL ANGLE OF ATTACK FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. ORIGINAL CONDITION — FABRIC FASTENED.

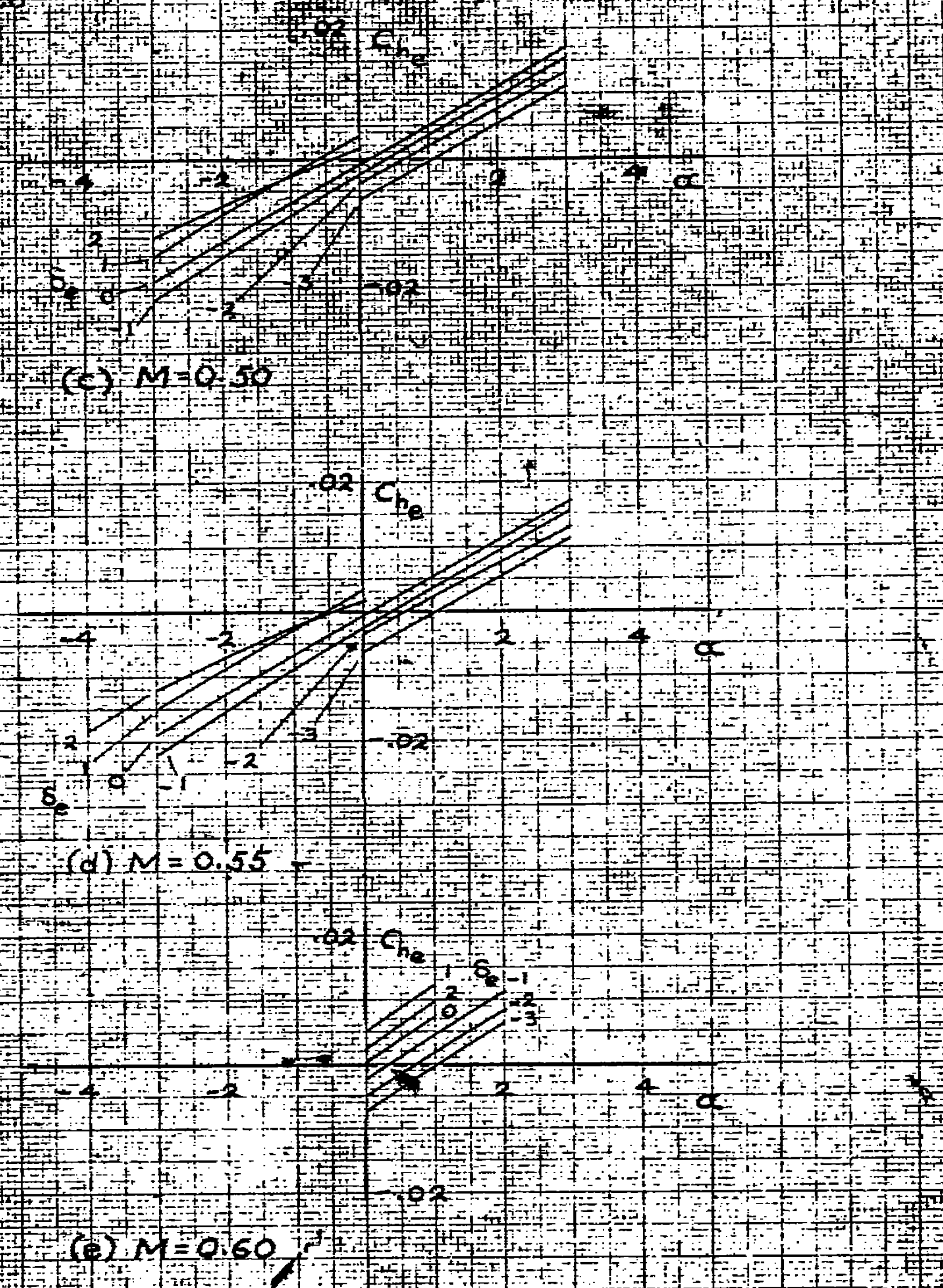


FIGURE 11. – (CONCLUDED)

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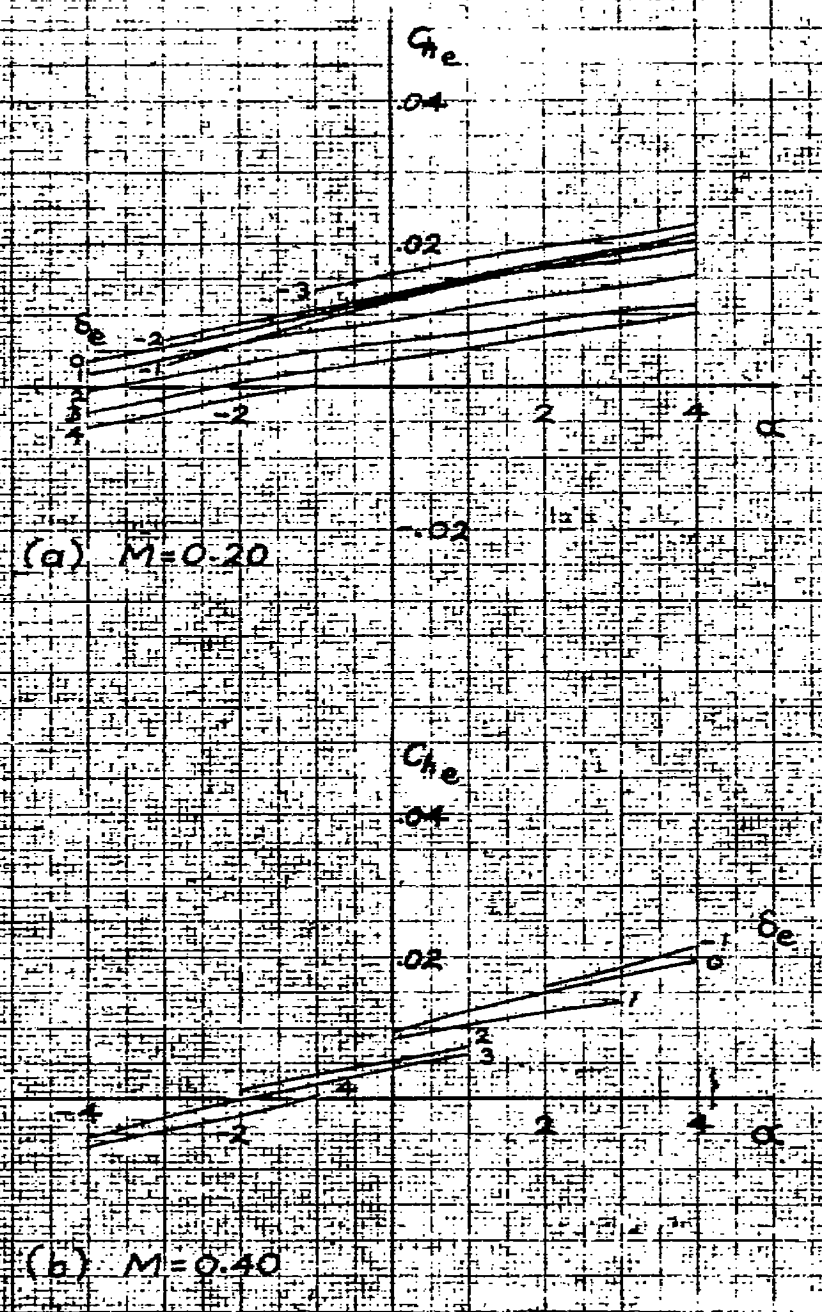

[redacted]

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FIGURE 12.- VARIATION OF THE ELEVATOR HINGE-MOMENT COEFFICIENT WITH TAIL ANGLE OF ATTACK FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. FABRIC FASTENED - DECREASED RIB SPACING.

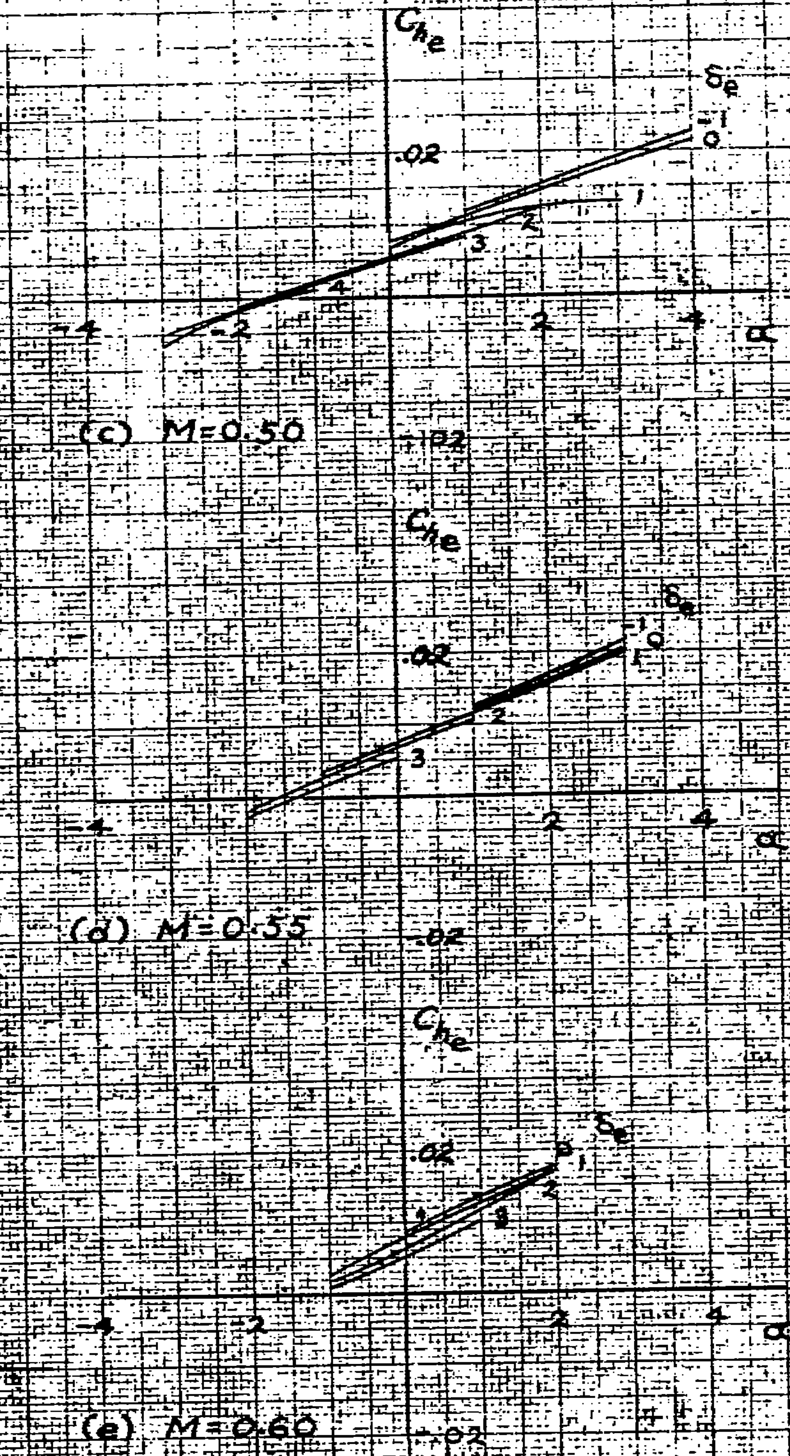


FIGURE 12.- (CONCLUDED)

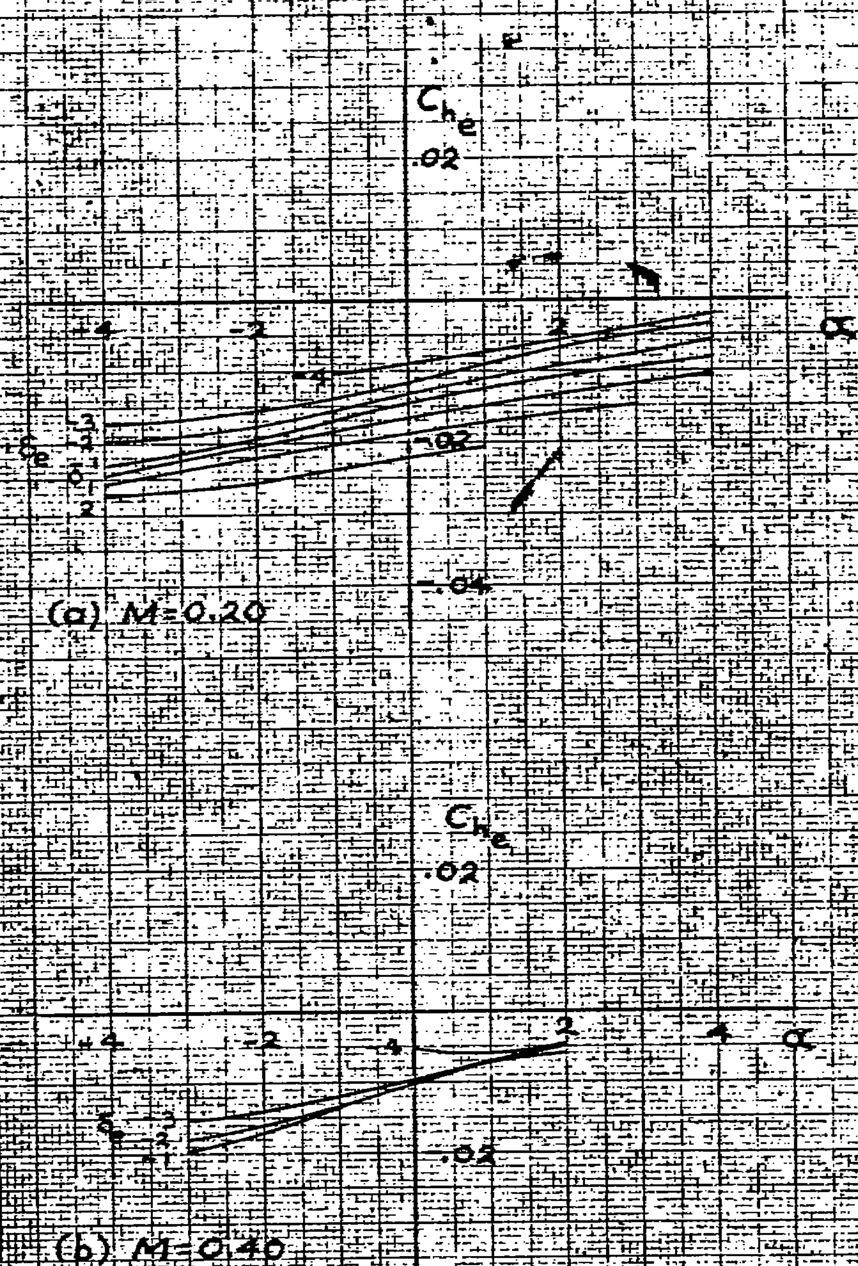
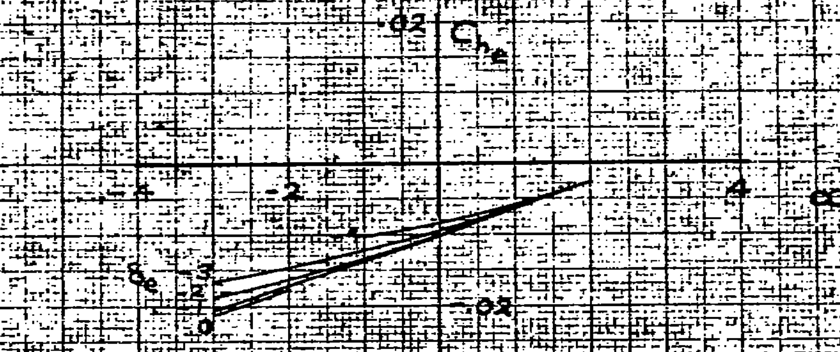
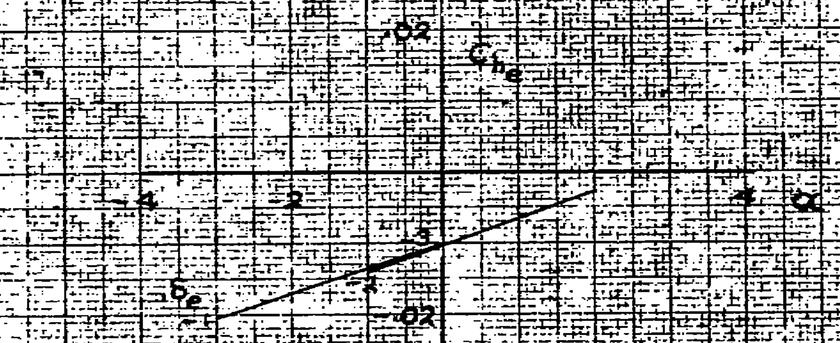


FIGURE 13 — VARIATION OF ELEVATOR HINGE-MOMENT COEFFICIENT WITH TAIL ANGLE OF ATTACK FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. FABRIC IN ORIGINAL CONDITION.



(c) M=0.50



(d) M=0.525

(e) M=0.55

FIGURE 13.—(CONCLUDED)

[redacted]

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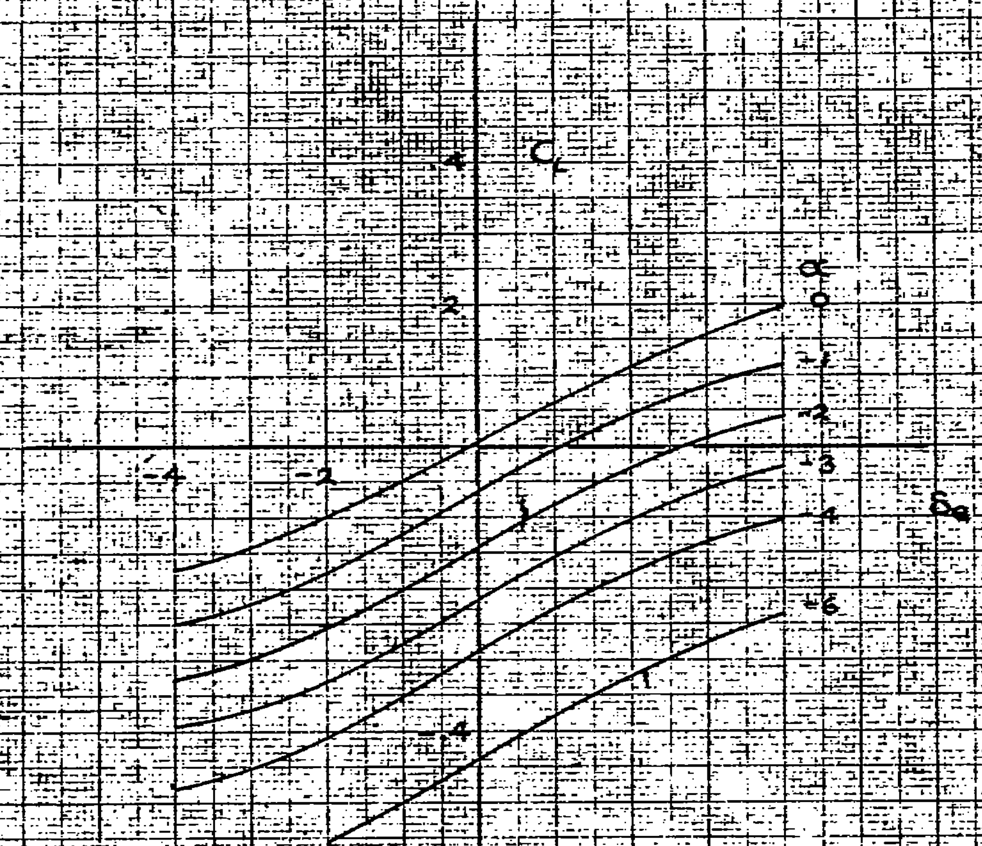

[redacted]
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FIGURE 14.– VARIATION OF TAIL LIFT COEFFICIENT WITH ELEVATOR ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. ORIGINAL CONDITION – FABRIC DETACHED. M = 0.20

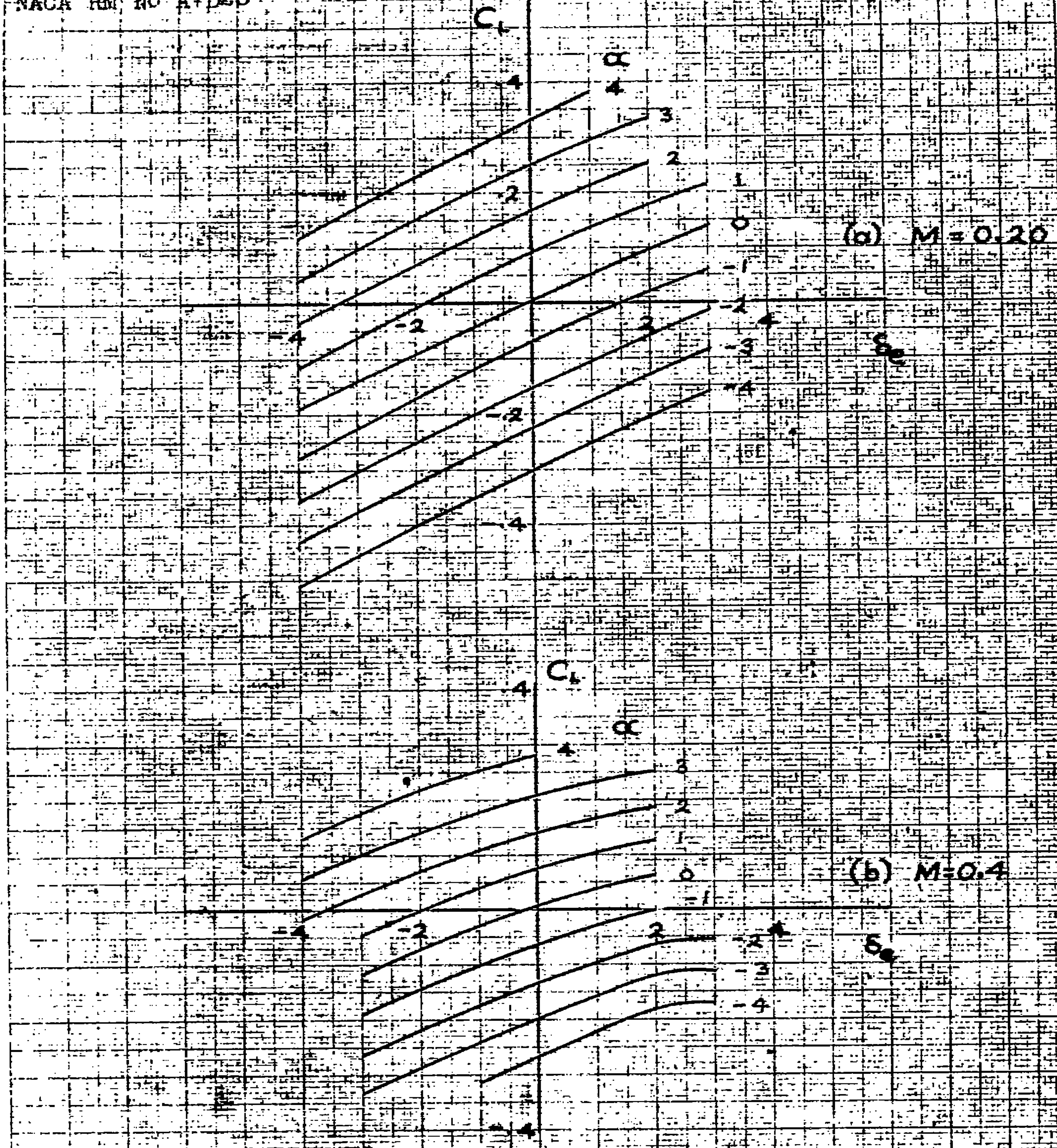

FIGURE 15.— VARIATION OF TAIL LIFT COEFFICIENT WITH ELEVATOR ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. ORIGINAL CONDITION—FABRIC FASTENED.

[redacted]

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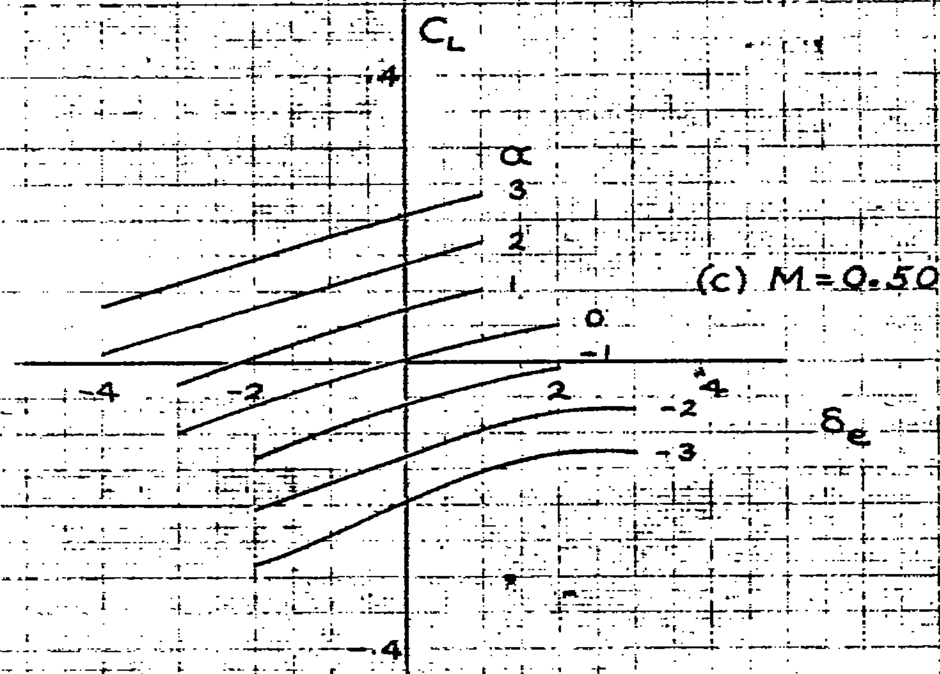

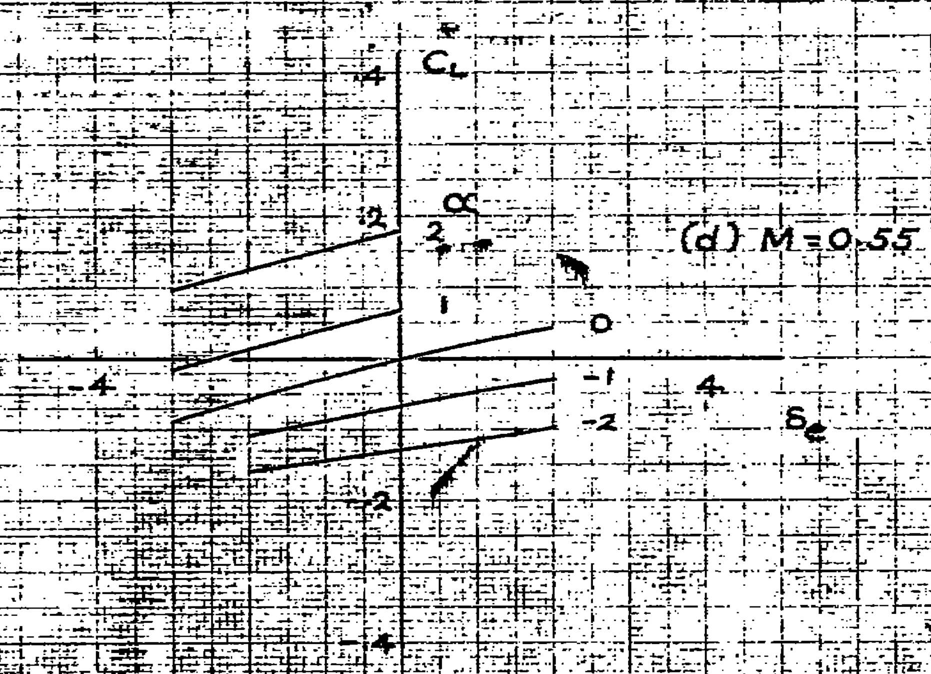

FIGURE 15 — (CONTINUED)

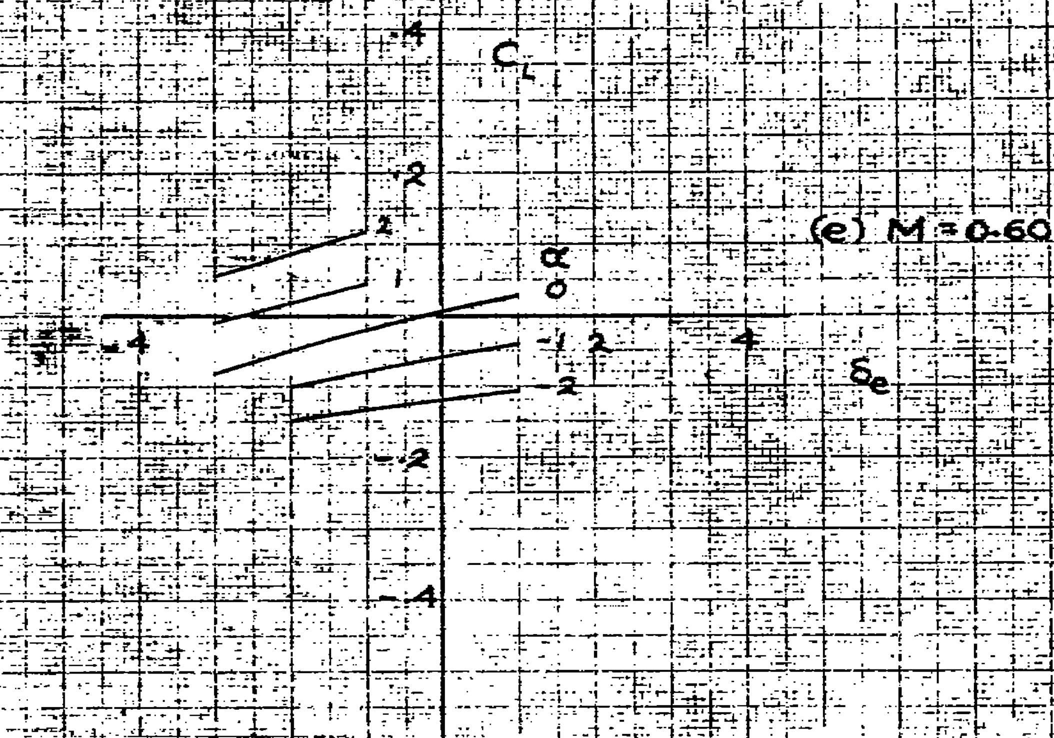

FIGURE 15.— (CONCLUDED)

[redacted]

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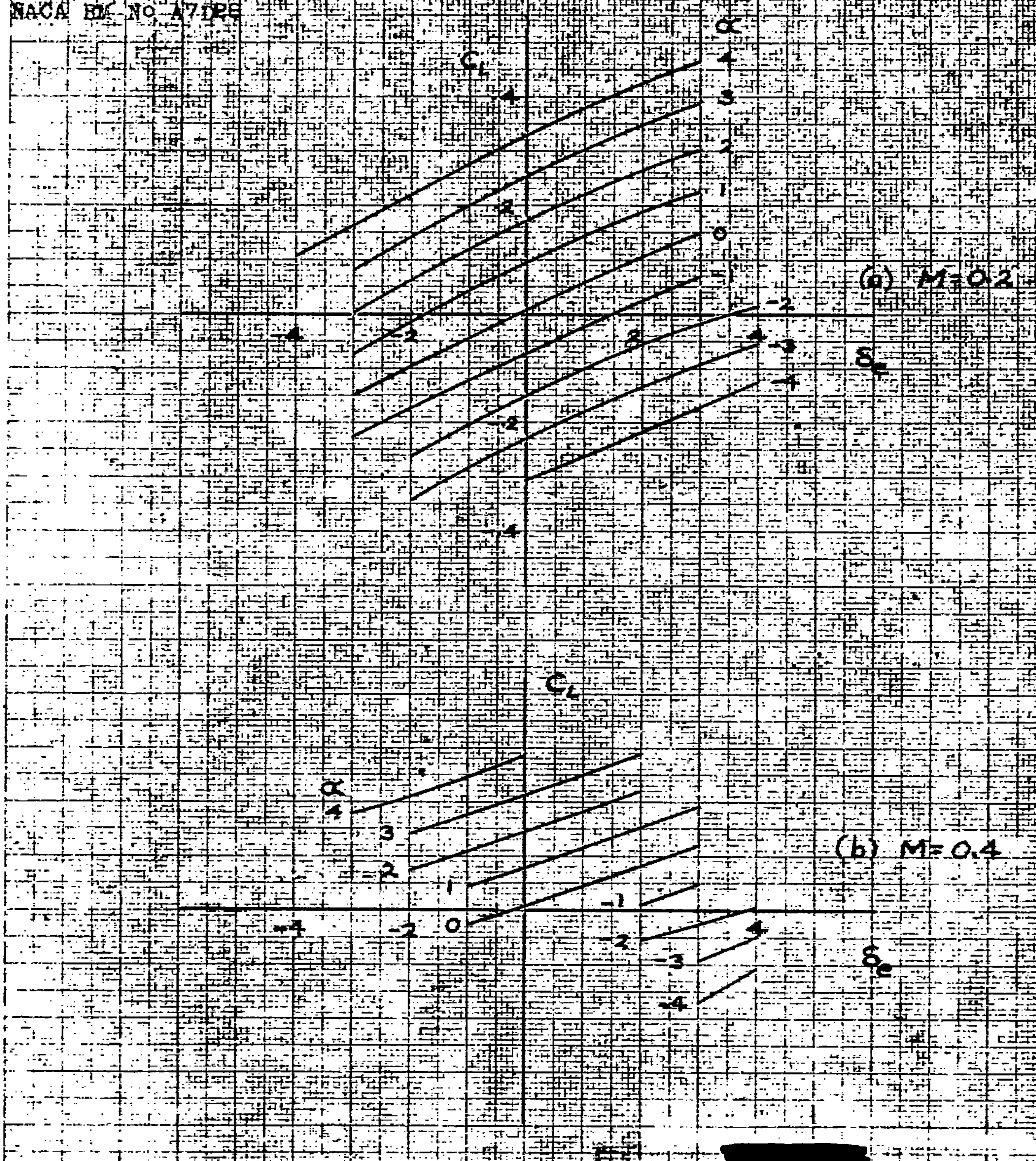

[redacted]

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FIGURE 16 — VARIATION OF TAIL LIFT COEFFICIENT WITH ELEVATOR ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. FABRIC FASTENED — DECREASED RIB SPACING.

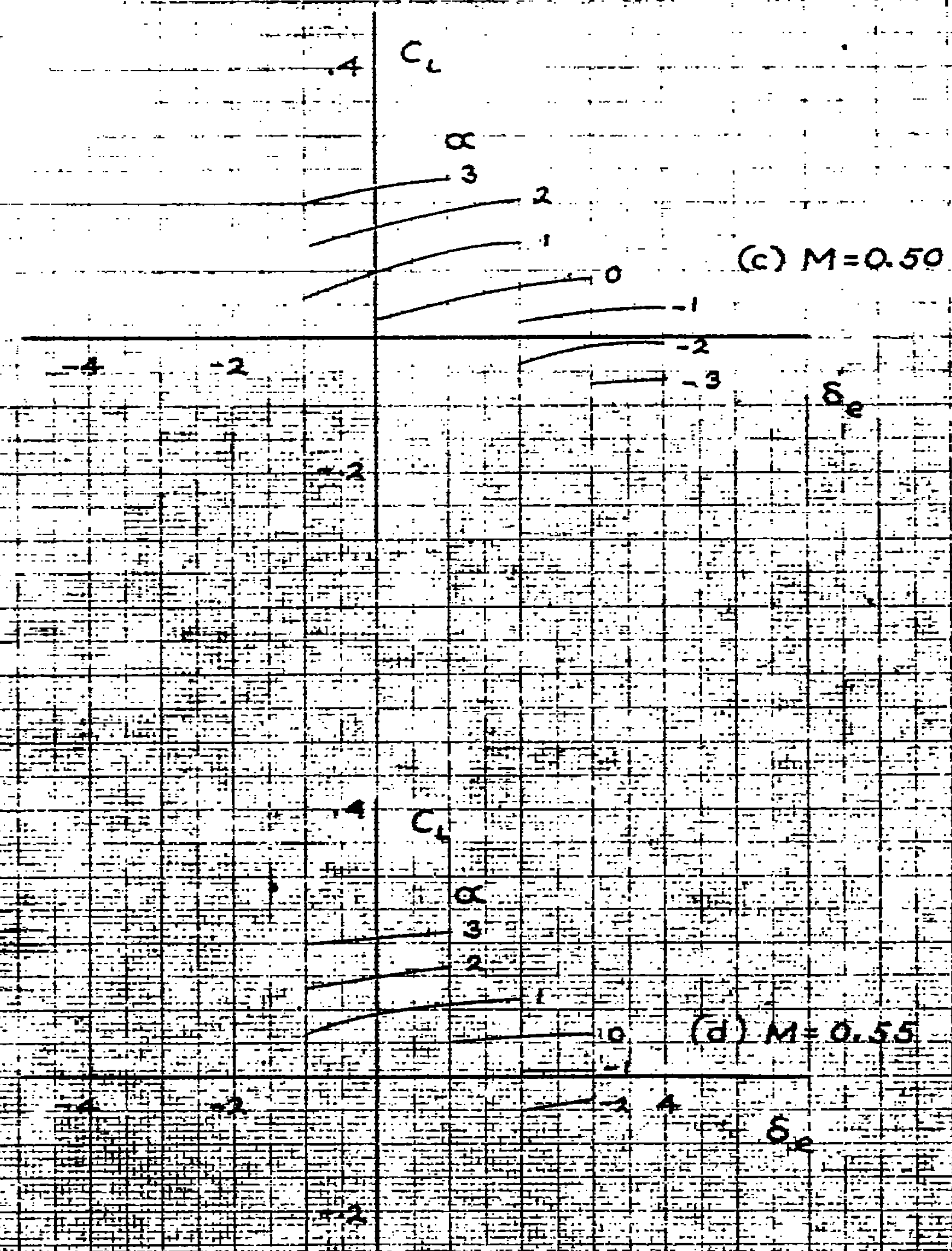

FIGURE 16.— (CONTINUED)

[redacted]
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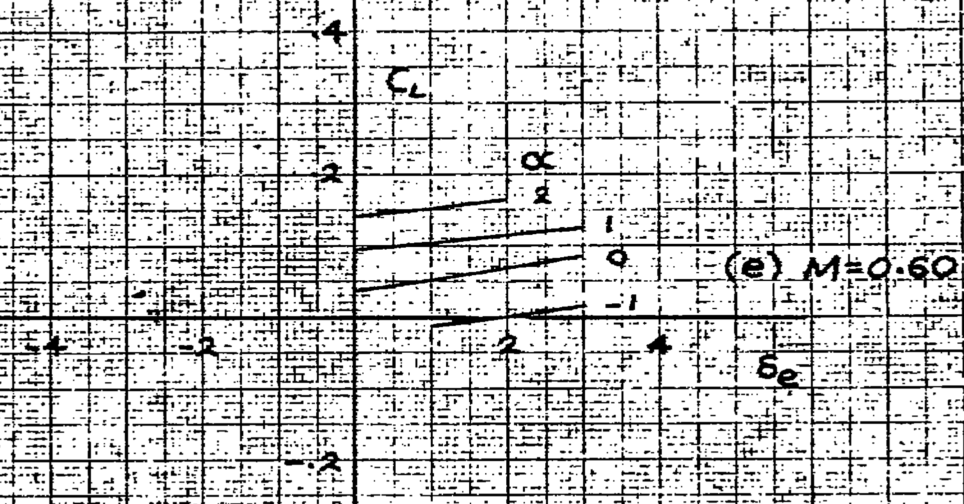

FIGURE 16.- (CONCLUDED)

[redacted]

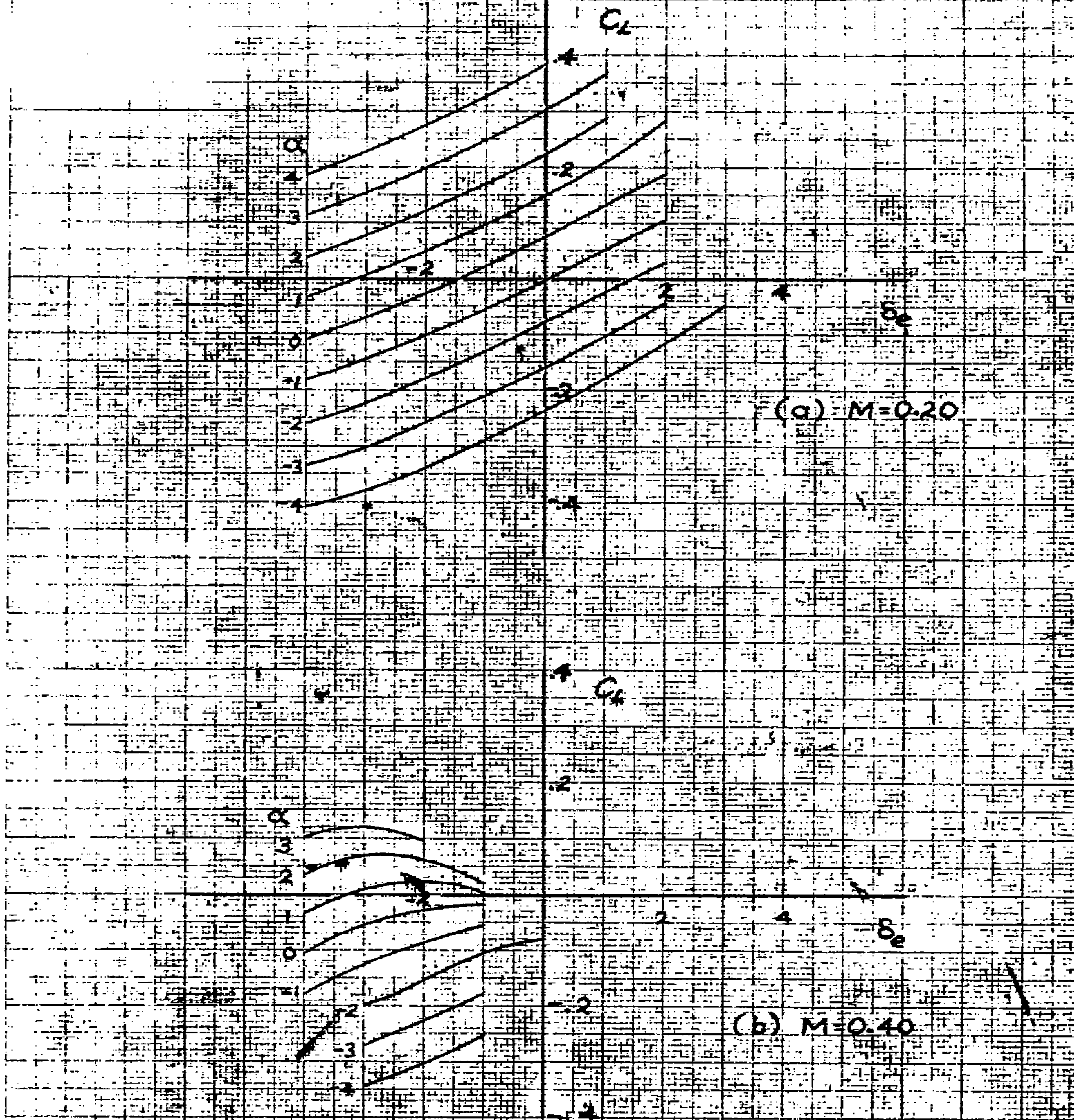

FIGURE 17.— VARIATION OF TAIL LIFT COEFFICIENT WITH ELEVATOR ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. FABRIC IN ORIGINAL CONDITION.

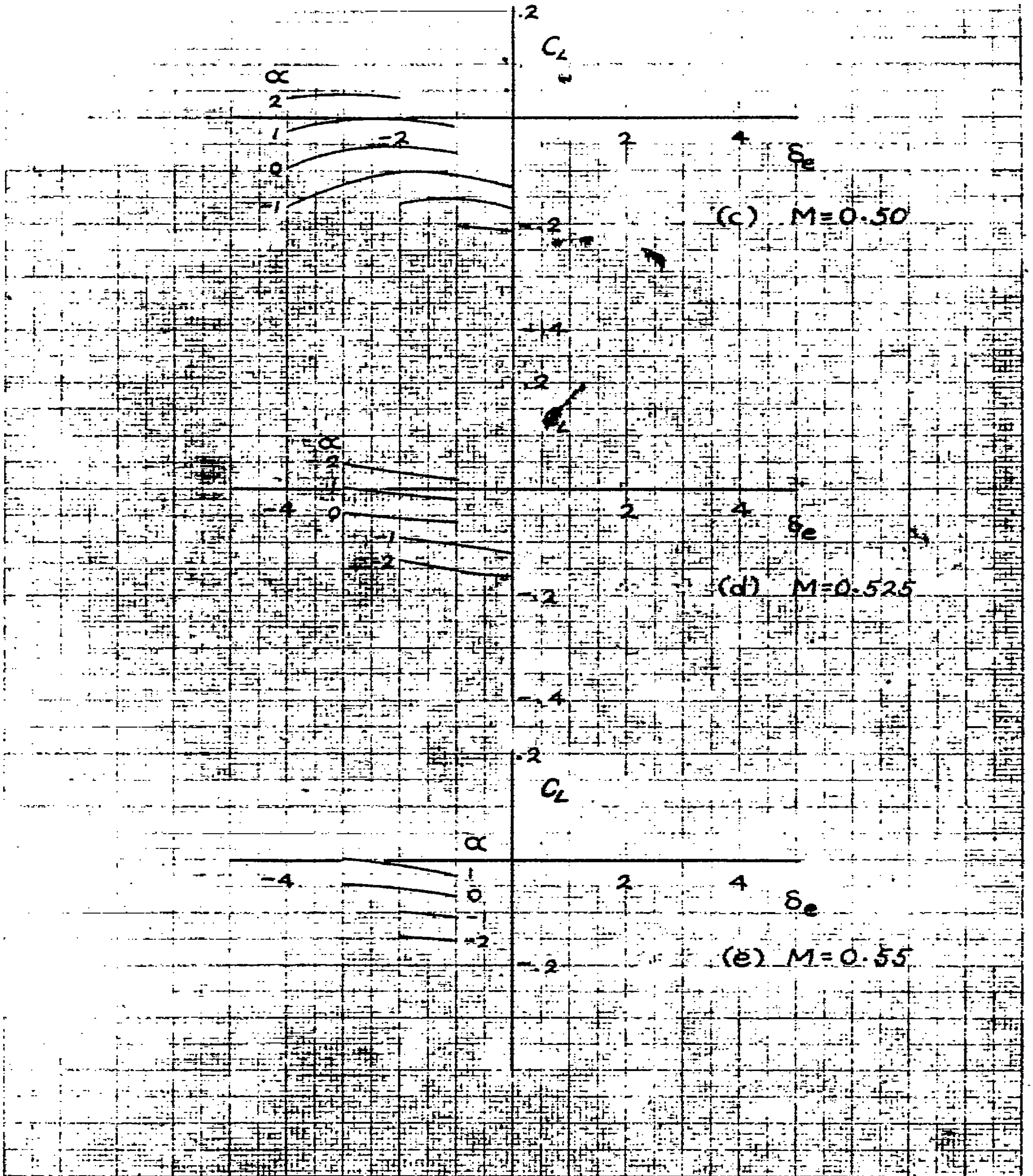

FIGURE 17.- (CONCLUDED)

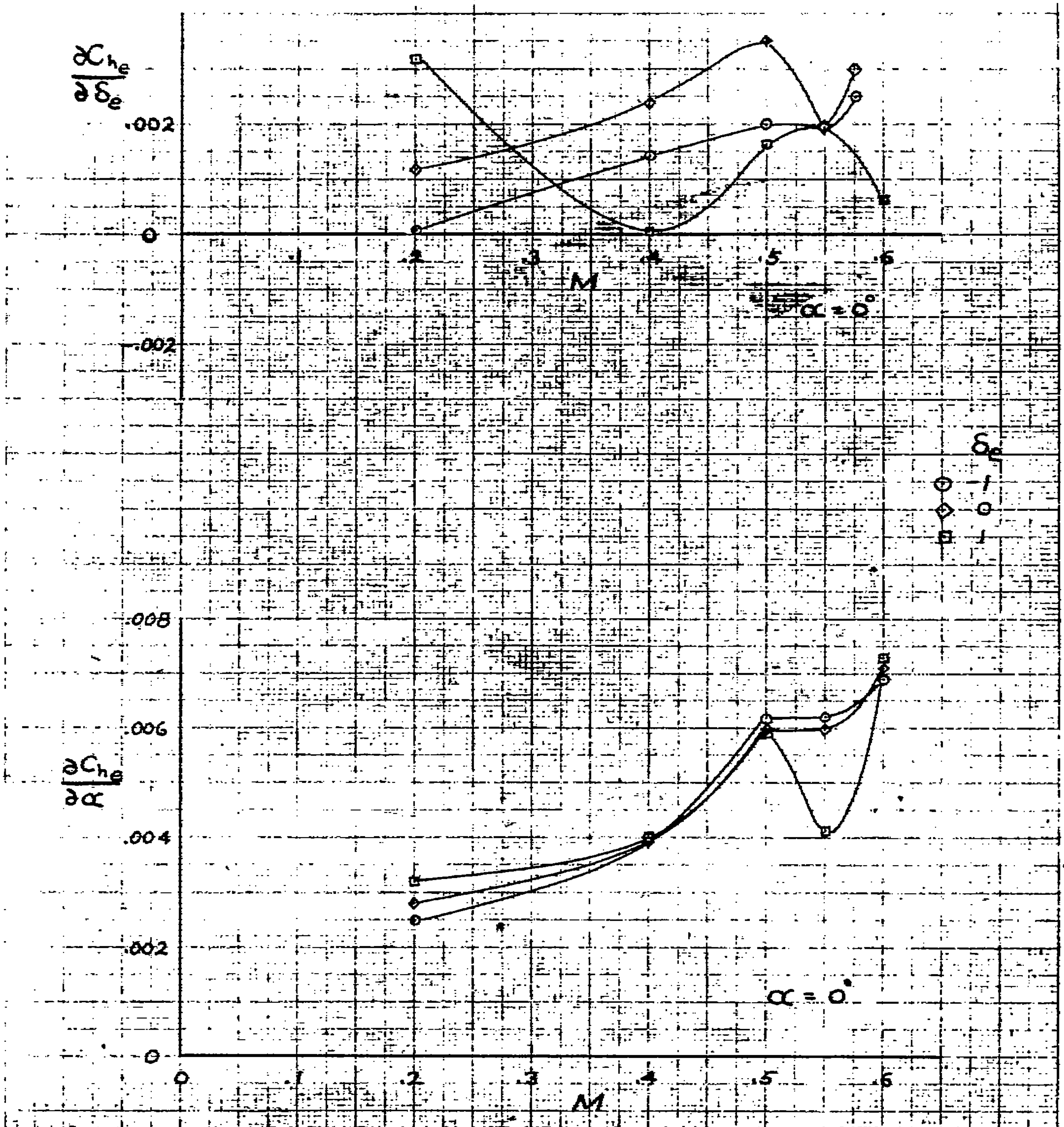

FIGURE 18.— VARIATION OF ELEVATOR HINGE-MOMENT PARAMETERS WITH MACH NUMBER FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. ORIGINAL CONDITION FABRIC FASTENED.

[redacted]

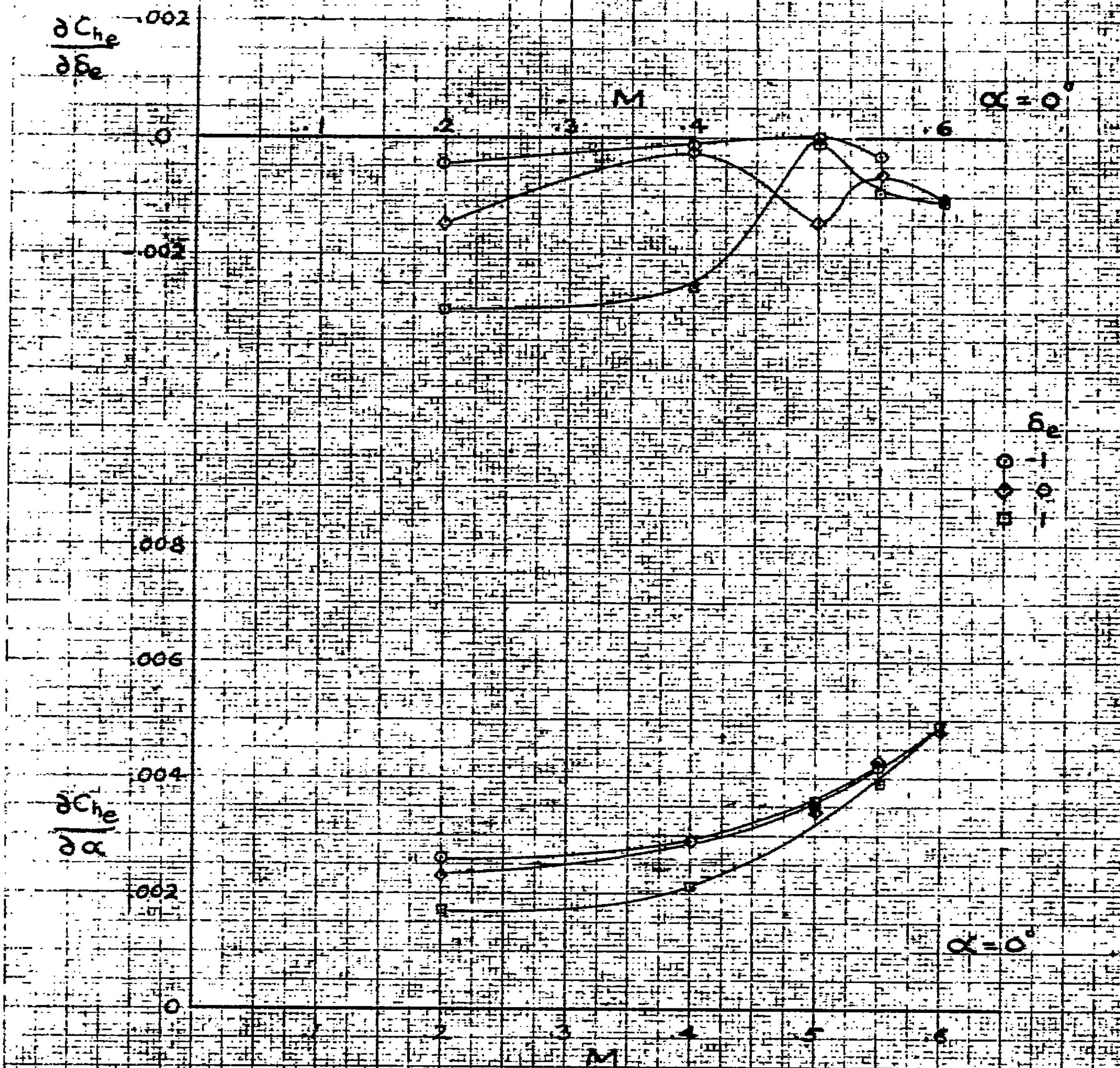

FIGURE 19.— VARIATION OF ELEVATOR HINGE-MOMENT PARAMETERS WITH MACH NUMBER FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. FABRIC FASTENED—DECREASED RIB SPACING. [redacted]

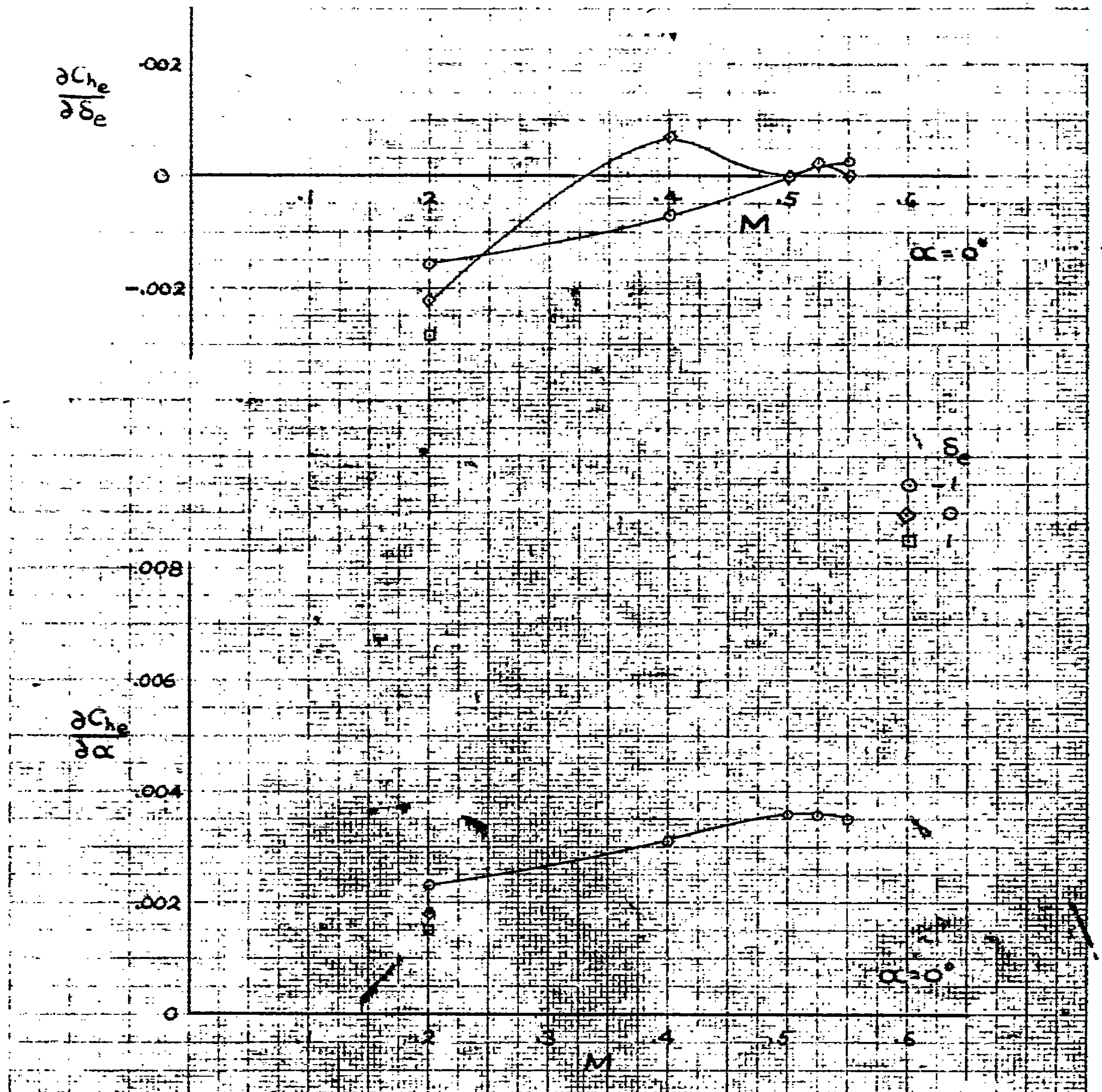

FIGURE 20.– VARIATION OF ELEVATOR HINGE-MOMENT PARAMETERS WITH MACH NUMBER FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. FABRIC IN ORIGINAL CONDITION. [redacted]

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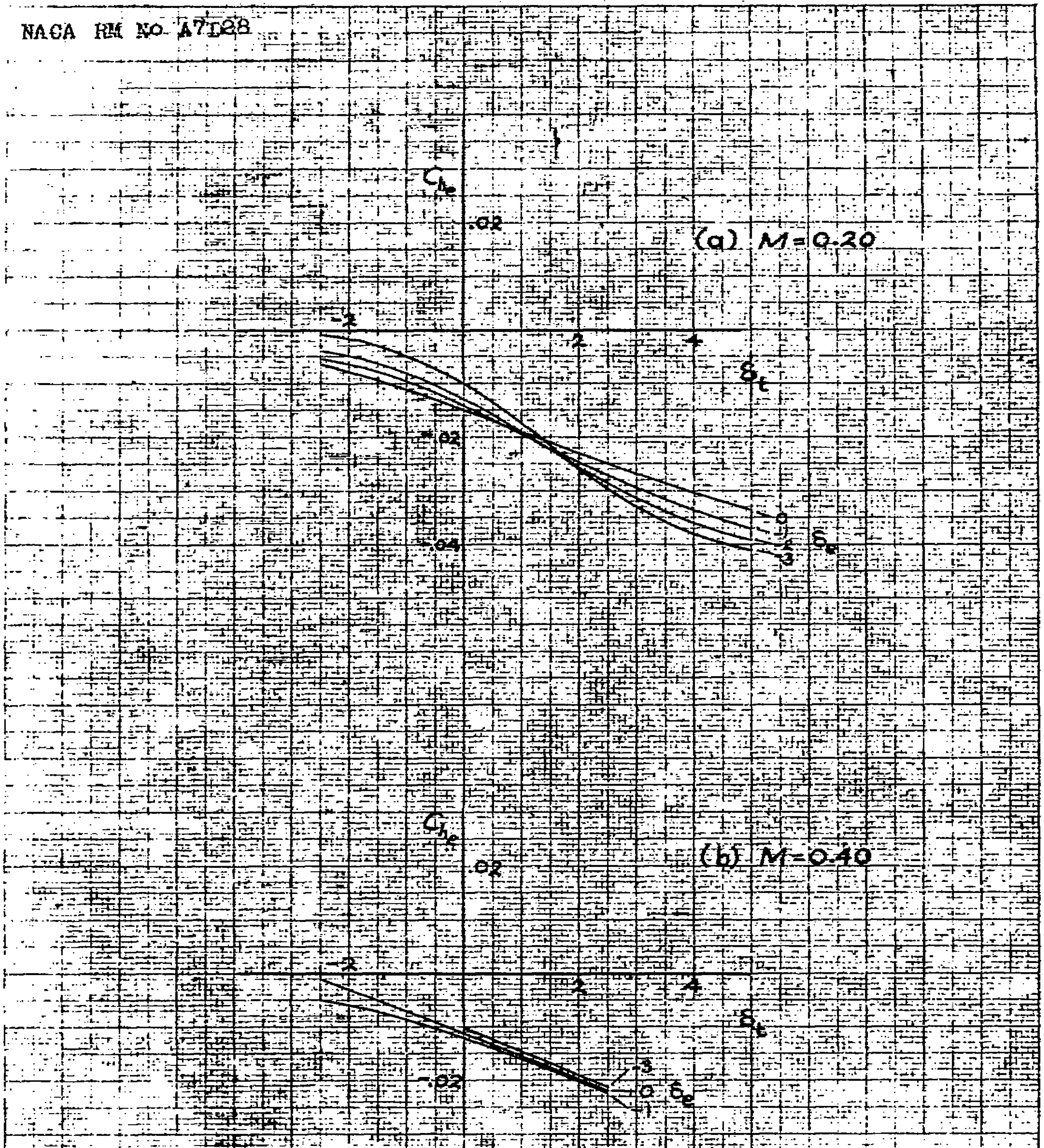
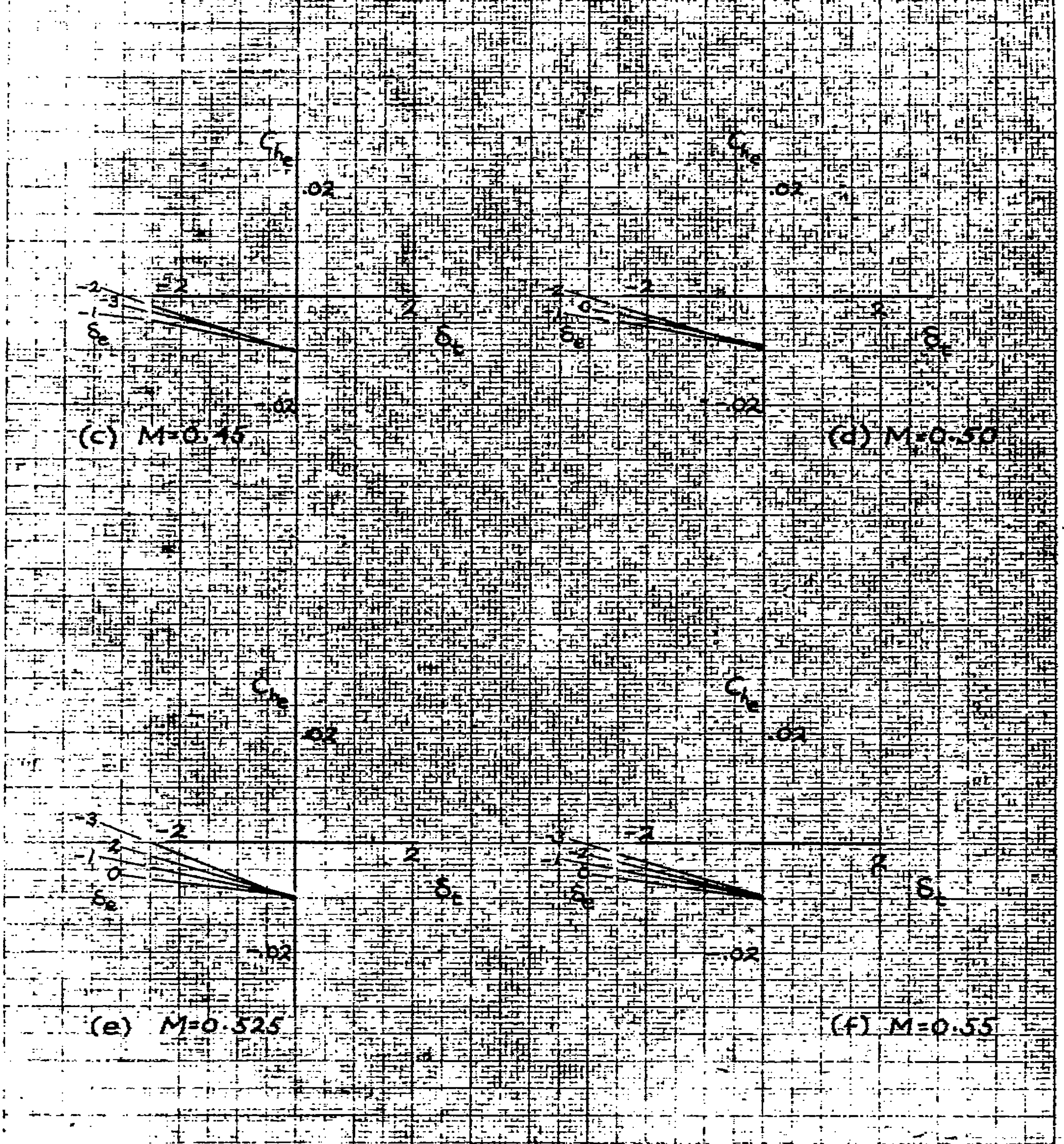


FIGURE 21.– VARIATION OF ELEVATOR HINGE-MOMENT WITH CONTROL TAB ANGLE FOR A SECTION OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE. FABRIC IN ORIGINAL CONDITION. $\alpha = 0°$.

[redacted]



[redacted]

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FIGURE 21.— (CONCLUDED)

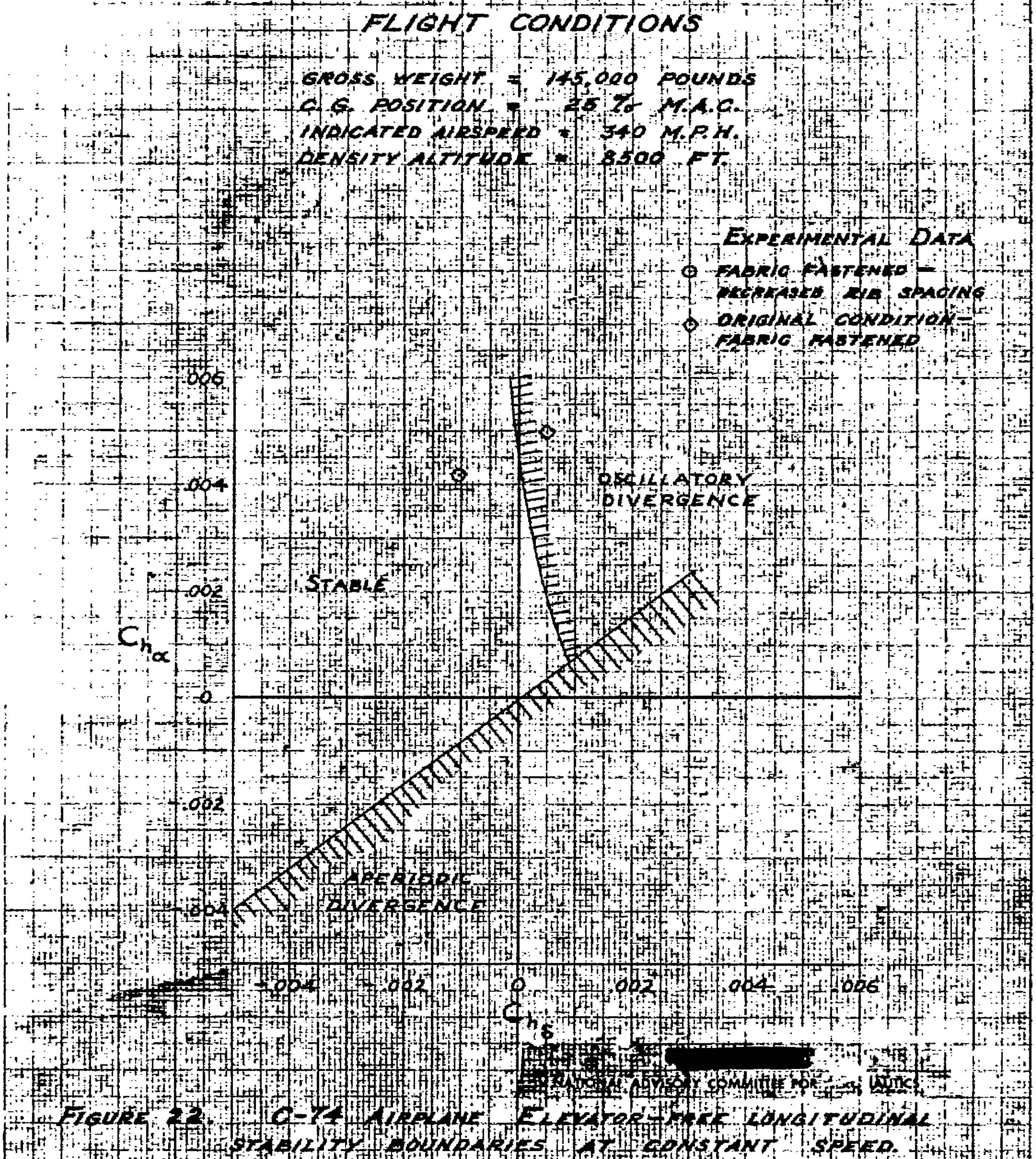
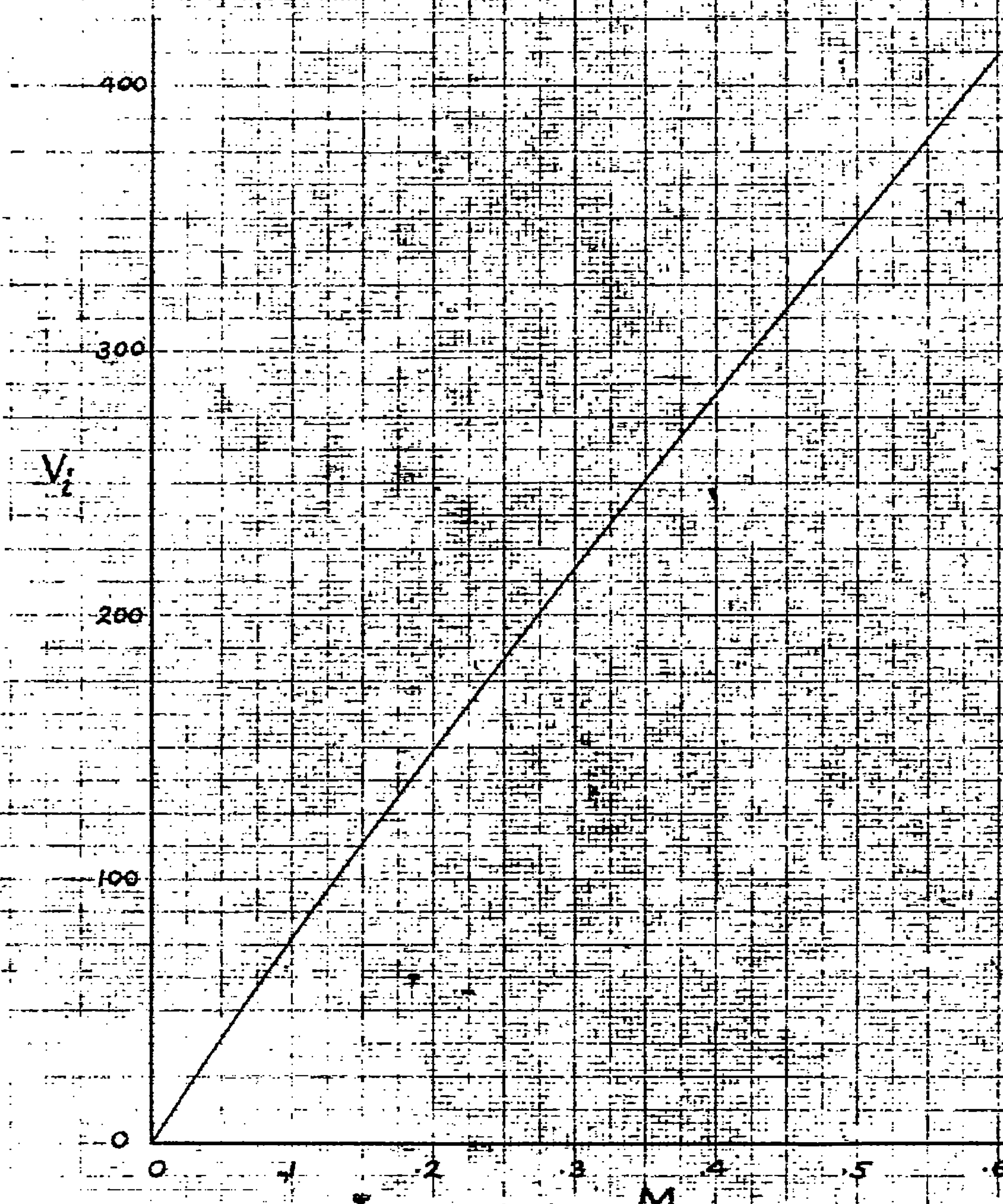


FIGURE 22. C-74 AIRPLANE ELEVATOR-FREE LONGITUDINAL STABILITY BOUNDARIES AT CONSTANT SPEED.

(STABILITY BOUNDARIES REPRODUCED FROM FIGURE PREPARED BY AERODYNAMICS DEPARTMENT, DOUGLAS AIRCRAFT CO. INC., 11-7-46)



[redacted]

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FIGURE 23.— VARIATION OF INDICATED AIRSPEED WITH MACH NUMBER FOR THE CONDITIONS IN THE WIND TUNNEL DURING TESTS OF THE HORIZONTAL TAIL FROM A DOUGLAS C-74 AIRPLANE.

H

Authors (2)

Elevators, Fabric - covered
Tail surfaces, Horizontal - Douglas C-74
Fabrics - Elevator covers - Distortion
Stability, Longitudinal - Dynamic
Tail surfaces - Hinge moments